TRAFFIC

ACCIDENTS AND CONGESTIO

MAXWELL HALSE

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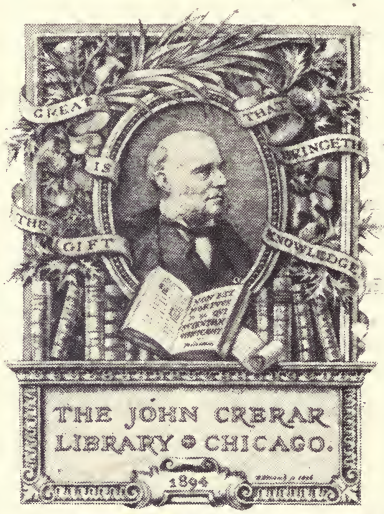

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TRAFFIC ACCIDENTS AND CONGESTION

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TRAFFIC ACCIDENTS AND CONGESTION

BY

MAXWELL HALSEY

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FOREWORD

This volume attempts to set forth the principles which underlie the scientific methods currently being developed to reduce traffic accidents and congestion. It should not be considered exhaustive, nor should it be regarded as a technical handbook. It aims to present a brief, well-rounded picture of the leading elements in the problem of accidents and congestion.

The book is thus intended not only for traffic students but also for those professionally engaged in traffic and highway engineering, for administrators and their staffs, teachers or supervisors, and others concerned with the protection or education of the public in the motorized world of today.

In keeping this discussion as non-technical as practicable the author has taken cognizance of the fact that the traffic problem, embracing both safety and congestion, is sorely in need of interpretation to the public. The growth of traffic has been so rapid and the techniques of dealing with it are so young that few have a sound understanding of it. Highway departments and city engineering departments are frequently placed in an unfavorable position because the public fails to understand the reasons behind their programs. If traffic inefficiencies are to be reduced, steps must be taken to improve public understanding.

It is hoped, therefore, that this publication will prove interesting among others to automobile editors, writers on traffic safety, and other newspaper and magazine writers who interpret the automotive scene to millions of readers. Newspapers have always been one of the most important media of interpretation. Newspapermen have frequently been at a disadvantage for lack of opportunity to study more deeply the subjects which they are called upon to interpret. The more a newspaperman knows about his subject, the better will be his interpretation. Few subjects in this country are of more fundamental or general interest than the traffic problem.

A word as to the scope and method of presentation of this book: It undertakes to cover briefly those phases of the automotive transportation field which have come to be known as traffic engineering and traffic planning. These represent the engineering approach to the problem of accidents and congestion as it affects the movement of persons and merchandise. The structural phases of highway engineering as regards supporting the vehicle are not covered; they are exceedingly important but have been adequately treated in other publications. Structural elements of design are covered only as their shape influences the efficiency of movement.

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The subject of mass transit operations has not been included. Admittedly it is of great importance to communities and warrants thorough treatment; but it is beyond the area of this book.

The approach to the traffic problem has been aimed equally at rural and urban conditions. Most of the points covered are applicable equally to cities and states, the difference being largely one of degree.

In attacking any problem it is essential that the broad picture be clearly seen and that all its parts be properly identified and placed in their proper position. For this reason, the text first establishes the points that (1) efficient transportation is the chief objective, and hence the core of the traffic problem; (2) present facilities are inadequate in many ways; (3) the engineer has a potential opportunity and responsibility for three-quarters of the problem; and (4) a rational approach must be made to the question of speed.

The subject matter is presented in five parts. The first, "Orientation," establishes the foundation. The second, "Organization and Administration," indicates how government should readjust its structure to operate most efficiently to improve transportation. The third, "Fitting Engineering to the Driver," indicates that the facility must be adjusted to fit human nature; the fourth, "Design Remedies," goes into some detail on the tools, processes, and methods of improving movement by automobile; and the fifth, "How to Attack the Problem," sets forth suggested procedures of analysis, measurement, and the preparation of plans and programs.

A summary precedes each basic point, which the subsequent text undertakes to explain and illustrate.

For purposes of clarity and reference, the material is arranged in sections or principles. These are not of equal value or breadth of application, but they serve to establish in convenient form the elements believed to be of controlling importance in traffic improvement. Additional elements may, of course, be fitted into the framework selected.

In order to clarify the presentation of material, make the more fundamental points stand out, and show their interrelation, each point is numbered and given a special heading. The first part of this heading, in capital letters, establishes the general principle. The second part of the heading brings the point in focus by explanation. The text immediately following summarizes the elements of the point established. The remaining text under each point shows some of its applications. Because of space limitations, the engineering data underlying these points have purposely been omitted.

Application of the principles here outlined would present a framework for evaluating all elements of the traffic problem—a task of compelling importance in so new a field. Some of the principles set forth may turn

out to be erroneous, but the *process* of working them out will have been a valuable one.

Unquestionably there will be many exceptions to the principles enumerated, but experience indicates that most of them are sound. At any rate it is hoped that they will stimulate further efforts toward sounder research and methods in the field of motor-vehicle traffic.

CREDIT AND ACKNOWLEDGMENT

The author wishes to give full credit to numerous colleagues without whose assistance this book could not have been completed.

Particular thanks should be expressed to members of the staff of the Bureau for Street Traffic Research, all of whom contributed freely of their time during its preparation. Acknowledgment is made of the assistance of Bryant Burkhard, of the Bureau, for photographs of traffic situations and for the preparation of models used in several illustrations. The use of models offers an illustrative technique for traffic more effective for some purposes than line drawings or direct photographs.

The author also wishes to express thanks to Dr. Edward L. Yordan for his editorial assistance.

Grateful appreciation is also conveyed to the twenty-seven men who served as visiting lecturers at the Bureau for Street Traffic Research during 1940. Their addresses and discussions proved a great stimulus to the author, as they did to the students.

Appreciation is expressed to the Rockefeller Foundation and to the Committee on Research in the Social Sciences of Harvard University for certain funds made available during the early stages of research which contributed to the materials and conclusions offered in this book.

A special word of appreciation is offered to the professional-spirited traffic officials, traffic engineers, and newspapermen who reviewed the manuscript and made detailed comments on the text. Their names are indicated with asterisks in the directory in Appendix A. Their remarks have done much to broaden, adjust, and confirm the opinions of the author. The testing of the manuscript in this fashion should lend weight to the ideas presented.

All the comments received and viewpoints expressed were given thorough consideration. In many places the wording was adjusted to be compatible with them, or to make the statement clearer. It is natural that there should be differences of opinion where adequate facts are not available. The author accepts full responsibility for all statements.

A word as to credit for the origin of ideas regarding traffic is in order. In a field as new as traffic engineering, at a stage where most of its principles and methods are still being developed and refined, it is difficult to assign credit to any person for a particular idea without finding that someone else had previously voiced an opinion the full application of which would include that idea.

It is especially difficult to award credit on any subject which has been treated by prominent men in the profession. Such men become a fountainhead of principles which are so widely distributed that their authorship is forgotten. The persons involved should not take offense but should feel compensated by the fact that their efforts have made a contribution to the field.

The author has no interest in claiming that he originated the ideas expressed. Because he has read widely and held innumerable conferences in this field with many of the most prominent traffic engineers, he would not have the temerity to lay first claim to any points. He is willing to let readers evaluate the relative merit of the thinking as it is set forth and draw their own conclusions on the basis of their own readings and conferences.

If the analysis contained in this book assists in providing an integrated picture of the field of automotive tranportation, and contributes in developing a basis of mutual understanding between traffic officials and the public, the author will feel that his efforts have been worthwhile.

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PART ONE

ORIENTATION

CHAPTER I

DELINEATING THE PROBLEM

Traffic accidents and congestion, a modern American problem only twenty years old in the critical sense, is now being thoroughly understood for the first time. Its development has been so rapid that the driver and the pedestrian have yet to adapt themselves fully to the motor age, and government to organize properly to control the situation. Since, in the past, however, many problems of mankind have yielded to the scientific approach, there is every hope that this one will give way before the application of intelligence. The time is ripe for a critical analysis of the American free-wheel transportation system as a whole. Clear thinking at this stage of development should establish the basic facts and set an orderly pattern for the future.

No real and lasting progress can be made in any field until its problems have been analyzed far below the surface. Far too often the surface indications are mistaken for the problem. This has been true in regard to street and highway traffic. The following are a few of the premature conclusions which were frantically accepted under pressure of a rapidly increasing death rate from motor-vehicle accidents:

False Concepts

1. Speed is the cause of all accidents.
2. Manufacturing of slower cars or installing governors on all cars would stop all accidents.
3. The answer to the accident problem is to take the fools off the highway.
4. If motor-vehicle drivers were as thoroughly trained as railway engineers, there would be no accidents.
5. All one has to do to stop accidents is to arrest more people.
6. Accidents are the real traffic problem and must be stopped by a carefully prepared attack aimed solely at accidents.
7. Lack of courtesy on the highway causes all accidents.

The above statements deal primarily with surface indications and contribute little or nothing to attacking the fundamental causes of the difficulty. These false concepts have served as a red herring which, unfortunately, has drawn many investigators off the trail of the real problem.

Courtesy Public Roads Administration.

Congestion proves inefficient transportation.

The Fundamental Problem is Efficient Transportation

Accidents Are Merely an Indication That Something Is Wrong. Accidents are not accidents at all in the literal sense of the word: they do not simply "befall." They have very definite causes, and these causes can be determined. They are primarily manifestations of underlying maladjustments. This does not mean that accidents, in and of themselves, are not exceedingly important in terms of human suffering. It means that they are even more important when viewed as an index of something fundamentally wrong. Undoubtedly, many of them can be prevented by an attack upon the fundamentals of the problem.

Congestion Is an Even More Evident Index That Something Is Wrong. Again, congestion is not the central problem. It is merely an index of inefficient motor transportation. It is a symptom through which the diagnostician may be assisted in searching out the fundamental difficulties.

The Movement of Persons and Merchandise Is the Root Problem. Persons and merchandise must be moved if business, society, and civilization are to progress. They must be moved even though during the early stages of development some persons will be injured and delayed. Increased efficiency in moving people and merchandise should mean a reduction in accidents and in delays.

It Is Useless to Try to Cure Accidents by Creating Congestion. Such actions are aimed at a superficial indication of the problem and are never able to overcome the basic urge for mobility. No arbitrary readjustment of movement at the expense of mobility will produce a lasting reduction in traffic accidents. As a practical matter this is true because the interest of the American people in transportation is so great that they will not stand for a disruption of their transport. It is doubly true because such an attack does not get at the basic causes.

It Is Equally Useless to Try to Cure Congestion by Increasing Hazard. Merely to attempt arbitrarily to speed up traffic in a particular locality in order to relieve congestion is not desirable. Traffic movements cannot be arbitrarily readjusted in favor of higher speeds. Such readjustments can be made only by strict attention to the functions of movement and the elements which actually restrict movement.

It should be quite clear that the American people are confronted with a tremendous transportation problem. That this problem exists is clearly established by the presence of certain inefficiencies. Prominent among them are inefficiencies which result in accidents, and those which result in congestion. To these must be added numerous other inefficiencies, including time losses, higher operating costs, and innumerable irritations and inconveniences.

There are grounds for the assertion that the basic causes of accident inefficiencies and congestion are identical. If the cause is present under high-speed light-volume conditions, it will frequently produce accidents. If it is present under low-speed heavy-volume conditions, it will frequently cause congestion. Combinations of these will naturally produce both accidents and congestion. The problem having been isolated, attention is now directed to the basic causes of the difficulty.

Basic Causes of Traffic Difficulty

It is doubtful that the basic causes are incompetence or malice on the part of the driver, lack of education and enforcement, or high velocity by itself. A careful analysis of the situation indicates that the following are controlling elements:

Angles of Movement, Including Incidence, Divergence, and Intersection. One vehicle traveling by itself in a straight line is not likely to get into difficulty as long as its projected path is unobstructed. The chief difficulty arises when this vehicle is forced to merge with the path of another vehicle, to intersect the path of a vehicle, or to diverge from the traffic stream. If these angles are controlled properly, the number of conflicting movements will be reduced. A reduction in these potential conflicts means a reduction in the exposure. If the drivers, in the mass, are assumed to be reasonably constant in their general performance, a reduction in the exposure will play a more important part in the reduction of traffic difficulty than any other single factor.

Courtesy Public Roads Administration.

Early transportation moved under difficulty.

Velocity Differences. Controlled speed alone is not hazardous. The problem arises only when a difference in velocity must be absorbed. If this difference is absorbed slowly, it produces congestion; if it is absorbed rapidly, it produces accidents. When velocity variations are combined with angles of movement, two complicated mental calculations are required of the driver. Each different angle provides a separate differential between the speeds of the vehicles involved. Each difference in speed must be integrated in terms of each angle. Furthermore, the ability of the motorist to judge some angles is much poorer than his ability to judge others; certainly his ability to judge speed at different angles varies markedly.

Hence it is reasonable to suppose that, the greater the number of favorable angles and the lesser the differentials of velocity provided in a roadway,

the fewer would be the conflicts and the simpler the formula which the motorist would be required to work out. The chief difficulties which speed contributes to the problem are that it lessens allowable perception time and tends to increase the severity of mishaps.

Obstructions to Movement. In addition to the obstruction of moving vehicles, innumerable stationary obstructions such as bridge abutments, culvert head-walls, trees, parked vehicles, building materials, curbings, and buildings play an important part in accidents and congestion.

Failure of the Roadway to Make Adequate Provision for Certain Functions of Movement. It is apparent that unless a roadway is functionally correct in design it will not provide for those elements which make facility of movement possible. If proper provision is not made for these, general pressures will be produced by driving conditions that will force human errors which, in turn, will produce accidents and congestion. The following are among the important provisions sometimes neglected.

Acceptable Speed. It is unlikely that motorists will stand for restriction of movement, that is safe movement, to the extent of one-half to one-fourth of that speed which the motorist desires and which his car is capable of giving both safely and economically. Provision must be made for over-all speeds which are acceptable. Naturally, traffic professionals will differ as to what those speeds should be, but the following figures may be suggested, merely as points for discussion.

1. Open highway, long distances: 60 to 70 miles per hour.
2. Outer fringe of suburban areas: 50 and 60 miles per hour for comparatively short distances.
3. Residential areas: speeds on parkways of 30 to 35 miles per hour for quite short distances.
4. Downtown sections: 20 to 25 miles per hour for very short distances.
5. Express highways leading to centers of cities: 50 miles per hour.

Note: These speeds will vary in different sections of the country.

It is probable that the American motorist is more interested in average speeds than in crest speeds and that he will be willing to travel at reduced speeds for short distances in downtown areas without too much complaint. Fulfilling these demands economically will necessitate special facilities over a small percentage of the roadway, and street systems which are functionally designed to carry traffic rapidly and safely. A motorist traveling an appreciable distance would proceed on present streets or highways to these new facilities, travel along them, and get off them near his destination.

Failure to provide some such arrangement undoubtedly leads many

motorists to overdrive the present inadequate facilities, thereby producing accidents. It also causes delays, owing to the inherent functional weaknesses of the present roadway system and the impossibility of increasing its capacity for safe speed without radical changes in functional design.

Ability to Pass. Most roadways must be provided with facilities for passing. This will continue to be true until the point is reached at which heavy trucks and motor cars are segregated and speed laws are enforced by public opinion. Overtaking facilities under light-volume conditions may be obtained by adequate sight distances, but as volume increases they must be provided by multi-lane roadways.

Entrances and Exits. Opportunities must be provided for entering and leaving the traffic streams with as little difference in velocity as possible within the cruising lane.

Convergence. Provision must be made for expanding two lanes to three, four, or six and for constricting six lanes into four, or four into three or two.

Volume Capacity. The capacity of different types of roadways must be increased to accommodate existing and future volumes. This may be accomplished by changing the functional design of roadways rather than by increasing the size or number of roadways of existing designs.

A careful study of these basic difficulties will show that they are just as applicable to accidents as to congestion. Hence the important point is to attack the basic causes rather than be concerned primarily with either accidents or congestion.

These Basic Difficulties Manifest Themselves in Four Types of Frictions:

1. Intersectional friction, resulting from right-angle movements at intersections.
2. Marginal friction, caused by interferences along the outer edge of the moving traffic stream.
3. Medial friction, caused by conflicts in the middle of the road between opposing streams of traffic.
4. Internal-stream friction, caused by differences in speed of vehicles moving in the same direction.

From the viewpoint of the ability of traffic professionals to reduce accidents and congestion markedly and thus to increase the efficiency of movement, the above classification may be very helpful.

The author believes that all accidents and congestion may be attributed to one of these four basic frictions and that each friction is just as likely to cause congestion as it is to cause accidents. Whichever inefficiency is produced will be determined primarily by velocity and volume of traffic.

CHAPTER II

THE CASE FOR THE ENGINEER

The driver by his performance upon the highway can contribute little to increasing the capacity of roadways. He can abstain from double-parking, weaving, and irregular movement. However, if the functional design of a roadway permits the passage of only 1200 vehicles per hour, there is practically nothing the driver can consciously do to increase this figure materially. Education, enforcement, motor-vehicle administration, and driver training are exceedingly important and should be vigorously applied to produce their maximum accomplishment. Their limitations with regard to some phases of the problem must, however, be recognized.

Thus, regarding one phase of the problem of transportation, the driver is relatively impotent. Whatever contributions the driver may make toward improving the traffic situation must, therefore, be in regard to reducing accidents or in demanding better streets and highways. Though without doubt he can make a reasonable contribution here, operating conditions today present so many complications that, even after economically justifiable efforts of education, enforcement, and motor-vehicle administration have been made, these complications will be beyond the ability of the individual. Errors will still be made, and a very large number of accidents will still occur.

The Driver as Such Can Contribute Comparatively Little to the Improvement of Automotive Transportation

In other words, there is a definite limit to the judgment of the average driver just as there is a definite limit to his reaction time. It would be exceedingly difficult, if not impossible, to improve this average very much. Both judgment and reaction will frequently be reduced far below normal by such factors as distraction and fatigue. As velocities increase, these normal human limitations become more and more critical. Thus the inability of the operator to remove a large proportion of the accidents is not fundamentally to his discredit, any more than the failure of operating

improvements introduced by educational and enforcement officials is chargeable to them. The significant fact lies in the inherent limitations of human nature.

If the average driver covers approximately 10,000 miles per year, it appears reasonable to assume that he will make at least ten mistakes during that time, some of which may take place under critical conditions. Since there are approximately 40,000,000 drivers, this provides the astounding total of 400,000,000 errors per year in the normal movement of traffic. With that many probable errors, the surprising fact is that there are not more accidents today. Increasing the driver's skill might reduce the number of errors. Other errors might be removed by increasing the willingness of the motorist to obey laws requiring him to travel at lower speeds than he considers desirable. There would still remain, however, a considerable number of natural errors which could not be removed by education or enforcement. There is nothing peculiar to drivers in these natural errors, since one has but to look around to discover similar errors in every field of human endeavor.

The failure of the human machine itself, a failure which is quite beyond remedy by education or enforcement, may well be the explanation for the great majority of the fatal or serious accidents caused by normal, law-abiding citizens. It is arguable that current roadway designs may be imposing upon drivers difficulties beyond their ability to cope with under normal operating conditions.

Since the driver can contribute practically nothing to the relief of congestion and comparatively little to the removal of accidents, the major improvement in the transportation system must come through improving the conditions under which vehicles must be operated.

The Engineering Approach Removes Basic Frictions and Physically Enforces Safe and Rapid Driving

The objectives of the engineer in attacking the transportation problem are: (1) to provide functional design and control in order to remove the present frictions; and (2) to compensate for human limitations by making numerous hazardous driving acts impossible as well as by encouraging sound driving acts.

The Limited Way Provides Functional Answers. A "limited way" may be defined as follows: A roadway reserved exclusively for vehicular traffic, providing no direct access to abutting property and therefore no incentive for parking or stopping except in emergencies, having no cross traffic through the provision of grade separations, separating opposite

streams of traffic by medial dividers, and providing acceleration and deceleration lanes for all entrances and exits.

Limited-Way Accident Reduction. Because of the functional characteristics of a limited way, it would be impossible for more than 15 per cent of the accidents typical in large cities to take place on such a roadway. Although precise estimation is most difficult, it seems reasonable that up to 40 per cent of urban traffic would use a limited-way system. If exposure is taken as a measure of the distribution of accidents, it would be a fair assumption that up to 40 per cent of the accidents would be affected by the transfer of 40 per cent of the movement to new facilities. Since, on these new facilities, only 15 per cent of these accidents could take place, only 15 per cent of this potential 40 per cent of accidents would take place on the limited-way system. This means that possibly only 6 per cent of the present accidents would take place on the new facilities as against the original 40 per cent. If the remaining 60 per cent is added, a total of 66 per cent, or a net saving of approximately 34 per cent of the total number of accidents, would result. This assumes that a reduction in the amount of through travel in downtown areas would reduce the exposure and thus the accidents. Regardless of the accuracy of these assumptions, it is obvious that the potential improvement is enormous and that the rate of improvement is particularly significant. If more travel can be had with the same number of accidents this itself represents a real improvement.

Basic Causes of Accidents and Congestion Identical

An attempt has been made to present the relationship between accidents and congestion. It has been indicated that the basic underlying causes of accidents are identical with the causes of congestion. It should be emphasized again that accidents and congestion are merely inefficiencies of the transportation system, and that their improvement must come primarily through engineering efforts to remove the causes of the surface indications. It is hoped, therefore, that the attention of traffic officials may be more closely directed to the real problem of automotive transportation so that the basic traffic "bacillus" may be isolated in each case. The removal of these traffic germs will, in most cases, reduce accident and congestion inefficiencies. The development of a limited way having functional elements scientifically designed to permit increased velocity and increased safety built within it holds great promise for the transportation system of the future.

Engineers Control About Three-Quarters of the Problem

If education, driver training, enforcement, and motor-vehicle administration could reduce traffic accidents 50 per cent everyone would agree that the work was highly commendable. However, many motorists would feel that, of the whole transportation problem, congestion is just as fundamental as accidents. If this is true, then for purposes of assigning values to different parts of the problem it can be assumed that accidents represent 50 per cent and congestion 50 per cent of the transportation problem. Thus the 50 per cent reduction in accidents would have solved only 25 per cent of the total problem. If the other 50 per cent of the accident problem is due to natural human error and cannot be reduced by the above agencies, then this 25 per cent is up to the engineer. Since he must eventually solve the congestion problem, that 50 per cent of the total problem, plus the remaining one-half of the accident problem, gives him a total of 75 per cent of the problem as his responsibility and opportunity. While police may reduce congestion to some extent through enforcement and directing traffic, especially under temporary emergency situations and at relatively few highly specialized locations, their over-all, nationwide effect on reducing congestion will be relatively small.

The importance of proper orientation cannot be overemphasized. Any department the members of whose staff are able to see a problem in its true perspective can do a great deal toward solving it. If, on the other hand, they do not see the true objectives clearly, much of their administrative and technical abilities will be wasted.

It should be pointed out most strongly that, though the engineer has the opportunity to solve three-quarters of the problem, he can accomplish very little unless he can obtain the full support of the administrative officials. This support will not come by itself; a definite program must be developed to secure it. Furthermore, because some of the highways now in use represent bonded indebtedness which must be amortized, some of the essential improvements will come slowly; the rate can be accelerated only after economic studies have shown that some of the improvements cannot afford to wait, and that additional expenditures at this time would represent a considerable saving.

Important specific points or elements of the problem may now be considered. These are set forth as specific principles, starting in Chapter III.

CHAPTER III

FUNDAMENTALS OF THE PROBLEM

It is as essential to spend effort to improve the speed of transportation as it is to spend it to reduce accidents. The automobile was not manufactured to save lives, or the roadway built to prevent injuries. They were made to move persons and merchandise. Thus, ultimately, the emphasis must be placed upon movement with safety rather than upon accident reduction alone.

The purchase of transportation by the automobile buyer is important to him. His desire for movement cannot be brushed aside by any *attack* on accidents at the expense of movement. In fact, in the long run it is unlikely that any accident-prevention measure can succeed unless it simultaneously contributes to motion. At least the net of all traffic efforts must facilitate the traffic movement, or transportation progress will be retarded.

People and merchandise must be moved. This function is vitally important to business and to society. No safety plan will succeed if it is based solely upon the slowing or stopping of traffic. Fortunately, what helps to reduce accidents also helps to facilitate movement.

Automotive Contributions. Perhaps a brief analysis of some samples of the contributions of the automotive transportation system to society will serve to show the vast potentialities for which the traffic engineer is striving. This new form of transportation, whose rapid development has been termed the Automotive Revolution, has improved our rural educational system by developing a rural school bus system, eliminating the inefficient little red schoolhouse. It has vastly improved our national health by bringing the doctor to the door quickly; by supplying previously unattainable fresh, perishable vegetables; as well as by increasing the accessibility of recreational areas in mountains, at the seashore, and at lakes. It has reduced the over-all cost of transportation, thus lowering the cost of merchandise in general. It has increased market areas, thus permitting larger and cheaper merchandising units; and has improved living conditions by making it possible for people to live farther from their work in less congested areas.

The above facts demonstrate that automotive transportation in the main has had, and may be expected to continue to have, an ever-increasing beneficial effect on business, society, and civilization.

Principle 1

EFFICIENT AUTOMOTIVE TRANSPORTATION, NOT ACCIDENT REDUCTION, IS THE FUNDAMENTAL PROBLEM. Accidents, Like Congestion, Are Only Indices of Inefficiency.

When these true values of the automobile are realized, it becomes evident that there is more to the problem than accidents. It becomes possible to place the emphasis upon movement rather than upon stoppage. This does not mean that accidents are unimportant and should be ignored. They are important inefficiencies that should be reduced or eliminated, just as delays are important inefficiencies that should be minimized. The fundamental point is that the basic functions of transportation should not be sacrificed for accidents. Thus the methods for reducing accidents should be of a type which do not render transportation even more inefficient.

This reasoning makes the prevention of accidents even more important than it is from the humanitarian point of view alone. Accidents not only cause untold suffering and grief, but they also are a symptom of inefficiency in the function of transportation, which is the orderly movement of traffic.

Time was when "safety" was not a popular subject. Today safety has been popularized to such an extent that some may be tempted to capitalize upon it, to the detriment of a broad attack on the problem.

In view of these important automotive contributions, successful solutions must be aimed primarily at improving the transportation system. These improvements naturally must deal with fundamentals, which in turn must be reduced to their basic elements.

Principle 2

AUTOMOTIVE TRANSPORTATION IS ESSENTIAL TO ORGANIZED SOCIETY. Mobility Is a Function of Modern Civilization.

The demands of automotive transportation cannot be ignored; nor can they be served by superficial steps. Broad plans must be made and carried out.

In the process of normal living no person can escape moving about, either as a motorist or as a pedestrian. Walking and riding are essential to business and to recreation. The inexorableness of this fact makes movement basic to civilization and thus subject to the same individual and fundamental treatment as public health, water supply, sewage disposal, or fire protection.

Just how basic transportation is may easily be demonstrated by the tenacity with which the motorist clings to his transportation. This tenacity comes from no whim but from the very real economic and other advantages derived from the automobile. Chief among these values is the ability to control the time and route of his necessary movements. It is significant that people in very low-income brackets will save money by giving up luxuries, and sometimes even essentials, in order to own a car. During the depression, this urge was further exhibited when many car owners apparently were willing to lose their homes rather than give up their cars.

It is also notable that a great many persons use their cars to drive such a short distance as four blocks, rather than walk.

Though the great bulk of workaday travel is from home to home, to station, to work, to play, and extends over comparatively short runs, the tendency to make longer runs is growing. It will continue to grow as the new time-saving facilities permit motorists to go farther during their spans of free time. Many a car owner will travel a considerable distance by car rather than by other means of transportation. The chief reasons are that he needs his car for use at his destination, that he can travel cross-country where there are no mass transportation services, and that he can be completely independent of schedules. In addition, other convenience and economy factors are involved in cross-country car travel, such as the avoidance of "Red Cap" and porter fees, taxi costs, and, where tourist camps are used, the saving in garage fees and bellboy tips, besides the distinct convenience of having the car so near one's room that it is not necessary to remove the luggage from the car. There are also the innumerable recreational advantages of getting out into the country not served by railroad or bus lines.

All these advantages have accrued to the motorist through the free-wheel characteristic of the automobile. He is quite aware of all these advantages. He is also more and more anxious to increase his average speeds so that he may reach out farther and farther on both business and recreational trips.

Impressive demonstration of this tendency is the willingness of the motorist to spend money for speedier facilities. He has spent several billions of dollars for automobiles during the last ten years, plus other billions for maintaining them, including expenditures for gas, oil, and tires. From the fact that he has permitted legislatures to appropriate highway building funds, it appears that he has quite willingly provided the money for the public officials to build about three million miles of highways.

Even the shock of having an accident is not enough to stop the motorist, for he will continue to drive after the accident. On the other hand, if a motorist is the victim of a serious delay at a particular point he will try to avoid that point in the future.

In view of all these elements, it is easy to estimate the attitude of the forty million motorists of this country. They insist on having transportation, and react against anything which will reduce the time-saving values made possible by the purchase of automobiles.

It has been argued that people use automobiles for transportation in cities where they should use some other form of transportation. It can be easily demonstrated that under some conditions people can travel more economically by bus, subway, train, or streetcar. There undoubtedly is an economic advantage in such cases. It has also been argued that mass transportation has been planned for. These two arguments are sometimes used to prove that people should go "downtown" in some other way than by automobile and that there is no economic justification for the provision of off-street parking facilities. While these points may be accurate on a minimum efficiency and economic basis, they completely ignore the highly practical point of how people want to go downtown. If people prefer to drive downtown and can afford it, then facilities must be built for them up to their ability to pay. The choice of mode of travel is their own; they cannot be forced to change on the strength of arguments of efficiency or economy unless the general standard of living were to be reduced far below its present level. Each form of transportation can win more customers primarily on the basis of the quality and flexibility of the service it provides, so long as it is within economic possibilities.

Principle 3

THE ROADWAY FACILITY FOR AUTOMOTIVE TRANSPORTATION MUST BE ACCEPTABLE. Government Has Assumed the Responsibility of Providing a Facility for Mobility. An Inherent Part of the Responsibility Is to Provide a Facility Which Offers Safe and Rapid Movement.

The roadway must be inherently safe and provide reasonably fast transportation. If numerous accidents and much congestion occur on a roadway, the transportation problem is not solved by placing the blame on the driver. The facility is built for him with his money, and its acceptability must be measured in terms of the degree of satisfactory transportation which it provides.

For example, having assumed the responsibility of water supply, government has accepted as an inherent part of that responsibility the provision of a water supply which is acceptable; in other words, water which is clean, pure, and suitable for drinking purposes. Similarly, government, having assumed the responsibility for providing a traffic facility, must provide one which is acceptable and permits safe and expeditious travel. If not, it might better turn the job over to private enterprise. This, however, would establish extensive toll structures and vested rights which would be difficult and expensive for government to recover later.

It is essential that highway departments evaluate the present acceptability of their roadways by reducing congestion and accidents to the common denominator of dollars. This measure would establish a foundation for comparing different roadways and sections of roadways. It would eventually show that there is a difference in the service which each mile of roadway produces. It would pick out the weak links or bottlenecks, which should receive preferential treatment because each dollar invested there would yield a greater return than on other stretches of roadway.

Once this time-saving basis has been established and the service of each mile of roadway determined, attention should be directed to the establishment of standards of performance which would then become the objectives of the department in charge. Responsible public officials should determine what average speeds they believe are acceptable for urban, suburban, rural, and open country. It would seem reasonable that these figures might be 20, 35, 50, and 70 miles per hour, all of which are below the actual performance characteristics of the automobile today and most of which have been proved to be within the capability of the operator today upon superior facilities. Here it should be pointed out that blanket speed regulations in cities would not permit some of these speeds. The fact remains, however,

that there is no magic about the "city limit" as far as the demands and functions of traffic are concerned. All new facilities should be designed for the speed which is required at each location. Each facility would thus naturally have its own speed limit, accurately adjusted to it.

These desirable standards having been established, the second step is to make careful estimates of the cost of the construction necessary to provide them. The time and accident savings must next be computed to show how much may be returned by investment in more construction and control

Courtesy Public Roads Administration.

The Appian Way withstood 2000 years of use.

devices and their maintenance. A comparison of the cost and savings figures then would show what could be economically justified. This would naturally differ in various parts of the country, being based primarily on the relative cost of property and construction, and the relative volumes of traffic and prevailing accident rates.

The third step is to determine the possibilities of financing the investments. This could be economically justified on the basis of savings to all motorists. Even though these savings existed in fact, if additional funds did not eventually come to the highway department such new projects

could not be underwritten. The one definite income item which would be certain in fact, but not in amount, would be the increase in gasoline consumption and gasoline tax revenue which would develop through increased travel. The amount of this induced traffic flow is a factor concerning which measurements are still in the development stage. The important point, however, is not how much can be immediately undertaken, but rather the development of a process of measurement which would eventually tell the highway department exactly where it stood and how fast it could move forward. This would determine the financial acceptability of each facility.

Principle 4

ALL ELEMENTS OF AUTOMOTIVE TRANSPORTATION MUST BE COORDINATED. The Facility Is Composed of Three Integral Parts: the Drivers, the Vehicles, and the Streets and Highways.

All three elements must be carefully coordinated. Lack of balance among them will cause innumerable difficulties which cannot be solved by working on any one.

The facility for transportation must include the selection, training, and control of the operators, and the provision of adequate vehicles and suitable roadways. It is essential that the fact be recognized that any facility for mobility or transportation must be considered as a whole and that each part must be considered in relation to the others. For example, the roadway must be considered in the light of the operators who are going to use it and the vehicles they will use.

These three factors are completely interlocked, and any forward movements must be made simultaneously. Traffic engineers are attempting to develop roadways and control equipment which will require a minimum of education and enforcement. Educators are trying to teach motorists how to drive more skilfully and to arouse public opinion in favor of traffic improvements. Police and motor-vehicle administrators are striving to make the motorists drive within the limitations of present roadways. Since there are hundreds of thousands of miles of roadways which must have new control devices, be redesigned, or be left for distribution purposes when replaced by new highways, the immediate importance of the police can easily be seen.

These parts make up the problem. If they were in perfect adjustment, there would be no problem. It is necessary to analyze the situation to see why they are not in balance.

The Driver. The driver has shown a most remarkable ability to adjust himself to new situations. Even so, the changes have come too fast for his driving abilities, developed until quite recently with no technical training in the various skills of driving.

The Automobile. The automobile is so far ahead of the driver and the roadway that it has actually caused difficulty. It has been perfected to a point where it is intrinsically safe and cannot be blamed for any appreciable part of the accidents. It has even been made so strong as to reduce to a considerable extent the severity of accidents when they do occur. The trouble it has caused arises from the "plus" factor of its capacity for faster travel than the present stage of highway development will permit with safety, and the inability of the driver to function at this high speed upon

inadequate roadways. The logical procedure is to improve the highway, not to make poorer automobiles. To try to manufacture or govern cars to a lower speed would probably cause more accidents, chiefly through reducing their ability to accelerate rapidly and pass in emergencies. The essence of an automobile is its mobility, just as the essence of a knife is its sharpness. To legislate slower cars would be just as ridiculous as to legislate duller knives.

The Highway. New roadway designs clearly indicate the possibilities offered in accident reduction through highway construction. They further suggest that the highway is the unit which is most in need of basic improvement, and through which vast and permanent transportation improvements can be made. This should in no way be taken as a criticism of the engineers who built the older roads, which represented a great improvement at that time.

PRESENT ROADWAYS LAG BEHIND CARS AND DRIVERS. The Vast Majority of Streets and Highways are Unable to Absorb the Potentials of the Vehicles and to Compensate for the Inherent Limitations of the Drivers.

Any maladjustment in factors of mobility makes accidents and congestion—i.e., "traffic inefficiency"—inevitable. Eighty-mile cars cannot be operated upon fifteen-mile streets and forty-mile highways by human beings endowed with a strong desire for mobility without making such restraint intolerable. Even in the face of enforcement, which may bring temporary forced adjustments, or educational efforts, which must move slowly and may never overcome the human desire for mobility, it is probable that drivers will overdrive the facilities provided for their use unless these facilities are designed properly for them and their vehicles and allow a degree of mobility in keeping with their potentials. New roadways should at least have built into them some margin for increases in speed which will probably come, as they have in the past. What good is it to give highways a structural life of twenty years or more if they are to be outmoded in ten years? Within the realm of economic justification, the potential safe speed of roadways must be raised to that of the automobile.

The most efficient transportation system is one in which there is a sound balance between the driver, the highway, and the vehicle. Throughout the history of automotive transportation these three factors have alternated in their advances. In the beginning the roadway was ahead of both the car and the driver. The vehicles were mechanically imperfect, and drivers were equally uncertain. With research and mass production, the tables were soon turned and the car had improved so much that it could absorb all the highway had to offer by way of movement, and drivers clamored for more facility. At that time drivers were not far behind because speeds were comparatively low. This sudden change confronted highway departments with the terrific problem of building primary roads and providing all-weather surfaces. The entire engineering profession should be proud of the magnificent job accomplished by highway engineers.

Effect of Velocity and Volume. At this point a new factor—increased velocity—entered the picture. This again placed the highway engineers in a dilemma, for, though they had solved the hard-surface structural problem, they had not designed the roadways for these higher speeds. In addition, the facilities were unable to handle the tremendously increased volumes. As speeds increased, the driver lagged behind as a factor, and driver training became increasingly important.

It should be indicated that an important factor holding back the engineer in new construction was the demand for a large mileage of hard-surfaced roads, which has created a heavy drain on highway funds through maintenance expenditures.

The point is worth stressing that the desired advancement of the roadway is not merely in terms of higher top speed. It is rather the necessity of making safe the average running speed which will meet the requirements of mobility. The ability of the average driver of tomorrow to handle cars safely upon intrinsically safe roadways at speeds of 60 miles per hour and up is unknown, but it should not be considered impossible *a priori.*

At the present time the roadway lags behind the cars in terms of capacity for volume and velocity, and lags behind average drivers in terms of mental and physical abilities. The revamping of existing roadways and the provision of new roadways to provide safe and rapid travel is the modern challenge to the highway engineer in his efforts to balance the transportation equation. This challenge is particularly stimulating because of the economic values at stake and the new methods of economic justification being developed.

Principle 6

IDEAL DESIGN SHOULD AUTOMATICALLY CARRY TRAFFIC SAFELY AND FLUENTLY. The True Function of the Roadway Is to Carry Traffic Safely and Efficiently. A Road Which Fails to Do This Falls Short of Performing an Acceptable Service.

Practically all traffic accidents and most congestion losses can be eliminated by improvements in design. A careful study should be made of these losses to determine how much can be economically justified as capital investment to improve the present level of transportation.

To blame the natural errors of drivers for traffic inefficiency is to have a wrong perspective. Even a highly trained railroad engineer would have just as many accidents as the average car operator if the transportation system were to provide him with grade crossings every 250 feet, a free choice of numerous lanes (one of which would make possible a head-on collision), and constant interference from both sides. It has been adequately demonstrated that roadways can be built in keeping with the requirements and potentials of operators and vehicles. These are generally called limited ways, freeways, or parkways. The West Side Highway in New York City and the Merritt Parkway in Connecticut, with remarkably low accident rates per million vehicle-miles, are outstanding examples. What is needed is to extend the principles which have already proved effective.

The acceptable roadway is one upon which accidents do not occur and upon which cars move rapidly. To meet this standard, the roadway must do two things: It must have capacity for the heavy volumes, and it must compensate for all human errors. This second is by far the harder for the engineer to accomplish. The fault may, in one sense, be that of the driver, but if that fault is inherent in human nature and cannot be removed, it is of little practical value to place the blame on the driver. In a sense it may be unjust, but the real burden of the solution falls on the engineer. It may be a large order, but it appears to be the most promising field for accident prevention.

This requires that the facility make certain dangerous driving acts impossible, eliminate critical decisions, and render safe maneuvers easier than unsafe ones. In short, the roadway must be of such design as to operate practically automatically.

Highways Can Drive the Car. The principle of having the highway, in effect, drive the car has only recently been discovered. Its possibilities may be said to be practically unlimited. The pioneering of this new technique will take considerable fortitude. The technique must make almost a clean break from past custom and habit and will undoubtedly be considered

an additional burden by the construction and maintenance men, who must be convinced that the additional effort is worthwhile in terms of reducing accidents and congestion.

It has been demonstrated that careful design can place the motorist in a particular lane and keep him there except when it is safe to allow him an additional lane in which to pass or a definite lane from which to turn. This has the effect of placing vehicles on rails and informs the operator of each car just where every other car is going to be and exactly where it has a chance to cross his path. This considerably simplifies the process of driving and eliminates numerous opportunities for error.

In time, the author believes, superior design will remove most driver decisions, prevent the great majority of improper and dangerous driving acts, and make desirable movements the easiest and most natural. Even if lack of funds will not always make ideal design possible, it is exceedingly important that such a goal be adopted and that strenuous efforts be made to attain it.

Dave Packwood.

Parking must be provided at convenient locations.

Principle 7

CONTROL OF PARKING AT THE CURB IS NOT THE FINAL ANSWER TO THE PARKING PROBLEM. To Have Utility, Vehicles Must Be Able to Load and Unload and Be Stored as Well as Move.

In some parts of the country, in the most congested areas of central business districts there is not even sufficient space to provide adequately for the loading and unloading of commercial vehicles, let alone for individual cars of customers. In the rest of the district, there is often not enough space for the customers' cars. Naturally, curb space should first be set aside for the loading and unloading of persons and merchandise. The remainder should be distributed equitably among the customers on the basis of the time needed. But all this allocation and distribution will still leave the demand only partially satisfied.

The solution to the loading, unloading, and storage problem must ultimately be found in the provision of off-street facilities. Loading bays must be made available by stores, and parking lots and garages by merchants, by private companies, or by the municipality, if it desires to provide all facilities for the effective use of the automobile.

Once this picture becomes clear, emphasis will be removed from the "red herring" of curb parking and concentrated upon providing off-street facilities. In many business areas the pressure has become so great that parking has had to be completely prohibited at the curb to make room for the essential loading and unloading of persons and merchandise. This pressure may even reach the point where movement will require all the space during peak hours.

The parking bugbear is no respecter of the size of the community. Not only does it frighten the great metropolis but it goes right down to the main street of every small community. The curb parking habit has been so strong that it has drawn the fire of government, business, and motorists. Even this space has not been used efficiently because of overtime parking wherever permitted by lax enforcement. It should be pointed out, however, that it is almost impossible to prohibit parking in one place if an alternative place is not made available for cars. Merely to keep on chasing the parker farther and farther away from his destination, the central business district or main street, is not the ultimate solution. It clogs up the residential streets, and a point is soon reached where the person driving downtown is forced to park so far away from his destination that he will no longer go downtown. This dries up the business market. The downtown stores must either move out to meet their customers or provide parking spaces for them. The same

principles apply to governmental functions and commuters. It might prove to be more economical to build parking facilities than to move out the shopping goods business, thus increasing its overhead through more units and lower volume, jeopardizing the tax structure of the community, and creating an unstable real-estate market.

While the curb space should be used as efficiently as possible, and parking meters may assist in doing this, the fact remains that in all the more concentrated business sections of most communities the time is soon coming when all the curb space will be required for the loading and unloading of persons and merchandise. When that happens there will be no parking for customers or for commuters. Against this day, all communities should make plans for providing off-street parking. Certainly the widening of a street to permit angle, mid-street, or even parallel parking has been shown to be outrageously expensive; furthermore, these measures impede traffic flow by making for irregular conflicting movements.

Plans for off-street parking should be made immediately, for it is apparent that, as business picks up, the present parking lots created by tearing down buildings to avoid paying taxes will disappear. If necessary, the owners of these lots should be encouraged in their parking business by a more favorable tax rate, justified on the basis of the public service they give. This might be supported on the public utility transition to government ownership in other fields. Business enterprise will probably take steps ahead of government in order to preserve its customers. Restrictive regulations should undoubtedly be removed in many localities to permit the provision of new parking facilities.

In view of the apparent trend, every community should immediately survey its parking requirements and start a sound program for meeting the parking demands of the future. Delay at this time will make off-street parking facilities more costly in the event of a rise in downtown property values.

Unless increased parking facilities can be provided, the utility of the automobile will be reduced. Thus parking and congestion, with their losses, must be studied to determine how much should be spent to make improvements, including provision of off-street facilities.

Principle 8

THE TRAFFIC PROBLEM MUST BE ATTACKED FROM FOURTEEN DIFFERENT APPROACHES. These Are Surveys, Research, Engineering, Planning, Education, Enforcement, Court Adjudication, Motor-Vehicle Registration and Driver Licensing, Organization, Administration, Legislation, Financing, Techniques, and Public Relations. Progress Cannot Be Made Unless All These Activities Are Pushed Ahead Concurrently.

1. **Surveys.** The provision of all the essential facts for showing what should be done and proving what has been accomplished.

2. **Research.** The development of better design, control, equipment, and methods of improving roadways.

3. **Engineering.** The attack through mechanical and physical elements such as signs, signals, markings, islands, design, and planning. This approach also provides accident analysis and the use of engineering methods in education and enforcement.

4. **Planning.** The development of a master plan of highway facilities in keeping with the requirements for the movement of persons and merchandise by automotive transport.

5. **Education.** The attack through teaching safety and traffic efficiency to adults, safe walking to elementary-school children, expert driving to high-school children and adults, and traffic engineering to college students and others.

6. **Enforcement.** The enforcement of traffic laws by the police and prosecuting attorneys.

7. **Adjudication.** The adjudication of traffic cases by the court to determine whether there has been a violation of law and to mete out adequate punishment.

8. **Motor-Vehicle Registration and Driver Licensing.** The control of drivers' licenses through examination, drivers' records, suspension and revocation, and the control of vehicle registration including motor-vehicle inspection.

9. **Organization.** The organization of all branches of professional groups and of the public into units and subdivisions to improve the traffic situation.

10. **Administration.** The efficient operation of traffic departments through personnel control, staff and line control, and coordination.

11. **Legislation.** The process of enacting traffic regulations establishing legal authority and detailing the rights and responsibilities of drivers, pedestrians, and units of government and their personnel.

12. Financing. The measurement of economic losses resulting from accidents and congestion, and the economic justification of traffic expenditures as well as the collection and equitable distribution of tax moneys for traffic improvements.

13. Techniques. The application of methods, techniques, and procedures as the detailed processes by which the above are accomplished.

14. Public Relations. The informing of the public concerning the operations of the department and the molding of public opinion in favor of sound traffic plans.

It is recommended that each traffic administrator make a check list showing exactly what is being done under each functional approach. Without such a list it will be almost impossible to evaluate the program because of the multitude of complexities.

CHAPTER IV

LIMITATIONS AND COLLATERAL FACTORS

No matter how thoroughly the motoring public can be convinced that enforcement is necessary, rigid enforcement will never be accepted satisfactorily and will eventually increase the hue and cry for a roadway system which will not require so much enforcement. It must be realized that enforcement is a form of education and as such should be applied in an educational manner.

Principle 9

ENFORCEMENT PRESSURE IS LIMITED BY THE LEVEL OF PUBLIC SAFETY EDUCATION. Enforcement Must Be Built up Slowly, and There Are Definite Limits to How Far It Can Go in Restraining Human Nature.

It is clearly established that those in authority cannot restrain or alter human behavior beyond a certain point—usually at a level established by persuading the individual and society of the necessity for such restraint. Hence the engineer and the enforcement official cannot, solely upon the basis of facts and analyses, conclude that certain actions would reduce accidents and thereupon proceed to apply them. For example, an increase in the number of arrests for traffic violations may for a time decrease the number of violations and therefore the number of accidents. However, unless the public has been convinced that this additional restraint is necessary, a strong reaction will set in, which almost inevitably will lead to so much pressure against officials that the net result will be fewer arrests than previously. If the engineer constructs a bypass around a particularly dangerous spot, the necessity for this apparent inconvenience must be established if it is to remain and be effective. It is therefore vital that any program of improvement be "sold" to the public.

It is evident that the highway engineer cannot look to the police officer for any final solution to the traffic problem. He must rely upon him for controlling speed and securing observance of traffic devices and rules, but even in this direction there is a definite limit to the degree of pressure the public will stand. Furthermore, the more the public is pressed, the more unfavorably will the motorists look upon the highway department which has created the factors requiring rigid enforcement.

Thus, only the accident half of the problem can be materially influenced by enforcement. Congestion and delay, another important phase, can be influenced only in a small way by enforcement.

Each school of thought naturally will believe in its own solution. Because the police think in terms of apprehension and punishment it is only natural for some of them to visualize these factors as the sole solution and to be quite unsympathetic toward the engineering approach. It is incumbent upon the traffic engineer to undertake carefully to explain to the police the functions of traffic engineering and how these functions can be of help to them, or to have the educational agencies accomplish this on his behalf.

A sympathetic understanding on the part of the police is essential to the traffic engineer because the engineer must have good accident records to

forecast and measure engineering improvements, and the police (as well as the motor-vehicle department) represent the original source of these records.

Although the punitive effect of enforcement is admittedly important from the outlook of the traffic engineer, in its present form and extent enforcement must be viewed as a necessary forced educational evil or stop-gap to be permitted until such time as less enforcement will be required on roadways which are intrinsically safer. This does not mean that enforcement can ever be completely eliminated. Rather it means that less and less enforcement should be required by future design. Under some conditions a considerable amount of enforcement may always be necessary, and in some locations it may be cheaper than construction improvements which would require less enforcement.

This means that the engineer must provide the solution for the entire problem of congestion and for that half of human error which cannot be changed by enforcement or education. If accidents and congestion are considered equal phases of the transportation problem, the engineer is the only man who can improve three-quarters of the total transportation problem.

THE FUNCTION OF REGULATIONS AND OF MECHANICAL CONTROL, AND OF EDUCATION AND ENFORCEMENT FOR THEIR OBSERVANCE, IS TO CONTROL AND FACILITATE THE USE OF THE ROADWAY. This Function Will Have To Be Very Strong Until New Highways Are Built That Will Not Have So Many Intrinsic Weaknesses or Need Such a High Degree of Restrictive Control.

Regulation, education, and enforcement represent instructions to motorists regarding their use of vehicles on streets and highways. It is quite obvious that, the more perfect the roadway, the less of this treatment will be required.

For example, the primary function of a traffic signal is to remove the decision from the operator whether to stop or go. The grade separation removes the necessity for such a decision to a considerable extent, since under good conditions of design the operator may always go; the intersection does not become a point of debate between two drivers wherein the winner may go while the loser comes to a dead stop. In similar fashion, the stop sign gives one driver the right-of-way over another, thus removing at least one decision. The ideal intersection becomes one which is automatic in its control and requires no regulatory signs or signals.

Most control mechanisms must really, from the point of view of final solution, be seen as temporary aids. They are to be used only until sufficient improvements are made to eliminate them. As traffic engineering techniques are applied, a great many of these "aids" will become superfluous.

However, it is equally true that at a great many places these "aids" will turn out to be a more economical way of keeping a situation under control than a redesign job or a new roadway. Furthermore, as new facilities are created, many of those which they replace will be relegated to be distributing or slower traffic service facilities, which by their nature will always require assistance.

At specialized locations these mechanical devices are important in and of themselves and will always be necessary. But under no circumstances should they be confused with the end product and substituted for sound design, which does not need them. Many intersections, for example, will go through several stages requiring mechanical assistance before the accident and congestion rate will warrant a rotary traffic circle or grade separation which can get along without such aid.

Since these control measures are so intimately connected with the work of the traffic engineer he must become proficient in their use. He should

become a member of any committee dealing with them and should take an active part in their formulation and administration.

It should be emphasized that each of these devices must be economically evaluated in terms of its cost and the savings which it produces. This is the only way in which the most economical solution to each traffic problem may be found.

Thus mechanical control, regulatory control, their enforcement and adjudication, and motor-vehicle administration should not be relied upon entirely by the engineer. He should try to design in a manner that will require as few of these devices as possible, but he should utilize them wherever they are required and where they are economically sound adjuncts to outmoded design.

Principle 11

THE AVERAGE DRIVER'S KNOWLEDGE OF COMPLICATED TRAFFIC REGULATIONS IS LIMITED. Traffic Regulations Must Be Simplified if Their Administration Is to Be Successful.

Until the laws are simplified and until each sign, installed only after an engineering study, notifies the motorist of the safe speed at which he may travel and that above which he will be arrested, officers of the law will have a difficult time. Until then the only effective process will be a carefully worked-out administrative and interpretative policy on the part of enforcement agencies.

The average person resents complication. He is unable to understand his insurance policy or his income-tax blank, and he finds the traffic regulations just as complicated. Of all regulations the one which seems to him the most nebulous is the *prima facie* speed law. Faced by a barrage of phrases like "reasonable and proper," "having due regard for the safety of others," "at all times having his car under control," about the application of which his opinion would probably differ from that of everyone else, he draws his own conclusions and is surprised when the officer does not agree with him. He goes out on the street or highway and sees signs, and he is further confused because they do not seem to fit conditions. It is not much help for the officer to inquire of the so-called violator whether he knows the law, or for the engineer to rely upon the statutes in working out his design.

Only a small number of rules can be constantly kept in mind during actual driving. The fewer the roadway requires, therefore, the safer it will be. This situation will become even more critical as traffic speeds increase, because motorists will have less time to decide how to apply rules.

It must be pointed out that while only slight reduction of accidents can be expected of complicated regulations, practically no reduction of congestion may be expected.

Special care must be taken in design or mechanical control not to rely, under critical conditions, upon a design which must be supported by some brand new regulation requiring the motorist to do something he has never done before. If the desired objective cannot be accomplished in any other way, a vast amount of initial education and enforcement of the new regulation will be required. A far sounder policy is to endeavor constantly, through proper design, to reduce the number of regulations; obviously, the fewer regulations, the fewer misunderstandings and violations there will be.

Even though traffic regulations are greatly simplified, observance of

them must still depend upon the judgment and willingness of the operator to comply. Since the driver's judgment is not always up to the complications presented to him, and under many conditions the rules must compete with conflicting desires on his part, they will fall far short of achieving perfect results. The more laws a roadway facility requires for successful operation, the less likely it will be in the long run to provide efficient operation.

Thus, again, the engineer is forced to fall back upon improvements in design for his lasting gains.

Principle 12

THE TRAFFIC PROBLEM MUST EVENTUALLY BE REDUCED TO A BASIS OF ECONOMICS: The Dollars-and-Cents Values of Losses and Gains Will Eventually Determine How Much Should Be Spent for Traffic Facilities. Similar Values Will Dictate Which Form of Transportation and What Degree of Flexible Service Travelers Desire and Will Pay for.

Tangible values are usually measured in monetary units. The advantages and disadvantages—the gains and the losses—of automotive transportation must eventually be accurately interpreted in terms of dollars. This is the only satisfactory tangible measure which can be applied in evaluating losses due to accidents and congestion and in determining how much should be spent to eliminate these losses. It is apparent that these inefficiencies are being paid for in cash through increased medical costs, insurance, and slower, more costly schedules requiring more cars and more drivers to do the same job. It would appear an intelligent course to devote the sums now being lost to make roadway improvements that would wipe out the losses. The first cost would be possibly equal to the losses now entailed, but removal of the losses would undoubtedly increase the utility of the facility, thus earning more funds that could be applied to it on a balanced-budget basis. Additional expenditures should then be made for traffic facilities as long as each expenditure was offset by savings in business and in personal transportation costs.

There is little doubt that considerably more funds could be spent for traffic facility improvements and that the actual dollar savings would more than offset the cost. It is further possible that the improved facilities, if properly used, could be paid for by increased gasoline-tax revenues which would accrue, without any necessary change in tax rates, from increased travel induced by the increased accessibility. The San Francisco bridges and the Holland Tunnel in New York are excellent examples of structures which have induced large volumes of travel. Naturally each situation must be studied separately to determine accurately how much traffic an area would be capable of generating.

A few examples will serve to illustrate the present loss and conservational or loss-prevention situation. Surveys conducted by the firm of Jenson, Bowen & Farrell in Toledo, Louisville, and Youngstown show that the citizens of those cities are not spending as much to prevent traffic losses per dollar as they are to prevent fire losses. In Youngstown, 18 cents was spent for the prevention of traffic accidents for each dollar of loss due to this cause, whereas 48 cents was spent for fire protection for each dollar of loss. In

Toledo, 34 cents was spent for accident prevention compared to $2.04 for fire prevention per dollar of loss. The figures for Louisville were 30 cents per dollar loss for accidents and 89 cents for fire. In boiler insurance, approximately four times as much money is spent to prevent boiler explosions as is spent paying for actual explosions. In other words, business expends money in order not to have explosions, rather than to be repaid for explosions after they have occurred. The traffic situation is still in the negative loss stage. It will probably remain in this stage until the actual economic losses have been accurately measured.

The same economic basis of the degree of service provided will eventually determine the people's choice of whether they will travel by automobile, bus, street car, subway, train, boat, or airplane. The actual cost of each form of transportation cannot be compared directly with any other, for the reason that there is a marked difference in the speed, comfort, and flexibility of service which each produces. No exponent of any form of transportation can intelligently argue that more people should use it because it costs less. Its claim to a larger share of the total transportation should be based on the quality and flexibility of its service.

It is especially important to recognize that the essence of transportation is time and time-saving. It is fallacious reasoning to argue that there is no point in saving a motorist five minutes because he will spend it in a cigar store talking to the clerk. What a man does with his saved time is his own business. The real issue is how much he wants that time. It seems clear that he does want it, because he is willing to pay for it, as is demonstrated by the payment of tolls on such structures as the Holland Tunnel, when the fee on the slower ferry is smaller. Anything that people are willing to pay for has economic value. Hence it is important that attention be directed toward time-saving and the processes of conveying payments from the motorists for time-saving to those agencies which build the streets and highways.

Principle 13

THE TRAFFIC ADMINISTRATOR MUST OBTAIN PUBLIC SUPPORT FOR HIS PROGRAM. This Support Will Not Come Automatically but Only through a Sound Public-Relations Program. Without it the Best Traffic Personnel, the Best Administrators, and the Best Technicians Cannot Make Their Maximum Contribution, for the Public Will Not Understand the Program or Lend Support to It.

Government has a responsibility to report to the public upon its accomplishments. It is not sufficient for the public official to do a competent job. The public needs to be posted on what is being done, and why. It will not be satisfied unless it is told frequently and thoroughly. This is the bulwark of the democratic system. In a sense, it is the counterpart of the practice of giving stockholders frequent reports of the progress of a corporation. The public cannot be expected to make a special point of finding out whether a department is doing a good job. Often the results of traffic engineering activities are not immediately apparent, so that it is inadvisable for the traffic engineer merely to make an improvement and to expect the motorist to notice the advantages produced. The traffic engineer as a public servant must, for his own protection, for the good of his department, and for the benefit of the public in his political jurisdiction, establish a public-relations program.

As a first step in this program, it is necessary for the official to analyze his job carefully and determine what the public expects of him and of his department. For the traffic engineer this is quite simple. Broadly stated, the public expects improved transportation facilities. It does not expect merely better concrete, macadam, soil mechanics, or structural steel, but is deeply concerned with whether the activities of the department make it possible for users to move rapidly and safely over the facility.

The second step of the official should be to analyze the present irritations and study the complaints received from motorists and taxpayers. This will indicate the points which must be attacked in his public-relations program.

Next, the public official must look over his stock of goods (as it were), and decide which of his operations are most evident to the public and can be most easily understood by or interpreted for it. These "high-appeal" traffic activities should be increased. Even an elementary study of the situation will show that most of these activities fall within the province of the traffic engineer, namely signs, signals, markings, islands, pavement surfaces, and traffic design.

The fourth step in the program is to study the different ways in which the public may be reached: newspapers, radio, magazines, schools, public addresses, committees, etc. Besides these, the display of models at exhibits and the conduct of inspection trips for public officials, legislators, and budget officials are particularly valuable.

From the above a specific public-relations program may be developed. After being "sold" to every member of the department, this program must be reduced to report form and a calendar for its accomplishment agreed upon.

The final step in the program is the assignment of responsibility for it to a member of the department specifically delegated to carry it out. As the merits of this procedure become evident, this one-man unit may eventually be expanded into a complete public-relations division, as has been done in several governmental agencies.

CHAPTER V

THE IMPORTANCE OF VELOCITY

The author is extremely anxious that nothing in this book should be interpreted as fostering higher speeds at the expense of safety. Safety is highly important from the humanitarian point of view but even more important from the efficiency point of view. Unfortunately the very word *speed* has come to mean *speeding* or going too fast. Horrible accidents have created such a furore that it is almost impossible to talk about speed rationally. Merely to mention speed is to run the risk of being classified as a speed maniac. But the fact that accidents have changed the connotation of a word should not result in causing professional people to back away from the problem or become confused. Transportation is so important that it deserves to be studied rationally.

A RATIONAL APPROACH MUST BE MADE TO THE SPEED QUESTION. Because of Accidents Speed Has Been Placed in an Unpopular Position. But Speed is the Essence of Transportation and Deserves Serious Consideration. Emphasis Must Be Given to Higher Safe Speed.

High Speeds. In the interests of the future of transportation the author has referred to speeds of 60, 70, and 80 miles per hour. If these are dangerous under all circumstances, then they should be eliminated. But if they have time values and can be attained safely at a cost which the motorist can pay, then they should be most carefully considered. They should not blindly be discarded as theoretical or impracticable. Many motorists in the West today driving 70 and 80 miles per hour feel that this speed is safe, economical, and desirable under proper conditions. Most of the people in the East who have not driven much in the West are likely to feel that such speeds are undesirable. This feeling reflects the environment of eastern roads more than it does any factual analysis. The fact that it probably would cost much more to build high-speed safe roads in the East than in the West does not mean that the possibility of its being economically sound should be disregarded.

Speed Not an Objective. Speed is not an objective; it is merely a means to an end. The end is to get from one place to another with the expenditure of as little time as possible. The average person desires to save this time in order to devote it to some other purpose, or else because time has a profit-and-loss value to his business. Thus the word speed should be thought of chiefly in terms of convenience and time-saving. There is a definite desire for the saving of time, and it is important to save time if possible.

No Malice in Speed. There seems to be a rather general misunderstanding regarding motorists who drive too fast for conditions. Some persons even go so far as to say that people deliberately drive too fast. This reasoning will not stand up under analysis. It would imply malice, and no one in ordinary daily law-abiding operations will maliciously do anything which would endanger his own life. Many motorists do drive too fast for conditions, but they do not think that they are doing so. If any driver realized that he was going so fast that there was a very real chance of his being killed, he would immediately slow down. The instinct of self-preservation is a strong one. The only sound conclusion that can be drawn is that motorists who drive too fast for conditions honestly and sincerely believe that they are safe. They can be blamed for inattention, poor judgment, or lack of driving skill, but not for intent or malice.

Speeding Indicates Desire for Time-Saving. Another sound conclusion may be drawn from the fact that many motorists overdrive present roadways. That is the greatest demonstration available of their desire to save time for other things and of the fact that they do not want to spend more time in driving at a more leisurely speed.

Driver Improvement Necessary. Something may be done, through education and enforcement, to teach the motorist to drive more in keeping with conditions, but nothing can be done to change his desire to save time and to go to places conveniently within the time at his disposal.

Education and Enforcement Important. Educational and enforcement processes are very important and should be utilized to their maximum effective tolerated extent. It must be recognized, however, that, though they can be highly effective in some ways, in other ways their effectiveness, at any rate over a long period, may be seriously questioned.

Enforceability of Driving Laws. Consideration should be given to the nature of restrictions which are to be enforced. When education and enforcement are assigned the job of educating and enforcing something which is quite contrary to the strong desire of people to save time, the assignment is a difficult one. The degree of difficulty will be determined by the difference between the speed which the motorist wants (his desire to save time) and the safe speed which the design of the street or highway permits. If this difference is great, the task of the educator and the enforcer will be difficult; if it is slight, the task will be much easier. If the difference is too great, the task is impossible from the practical as well as the economic point of view. Thus the educator and the enforcer should hope that the engineer will be able to provide facilities which will make their job effective or at least possible.

Desires of Motorist and Business. What does the motorist want? After all, since most families drive cars and pay taxes, their public servants, including the educators, the enforcers, and the engineers, should strive primarily to give them what they want. No sound policy can be established until this controlling factor has been established.

Present Facilities Do Not Meet the Demands. The first point which stands out clearly in this analysis is that the motorist wants a great deal more speed and safety than he is getting. This is clearly demonstrated by the fact that he is overdriving most of the present facilities. Thus it may be accepted that in the future the engineer must give the motorist roadways which have a higher factor of time saving than most of the present ones. In other words, the engineer must give him higher safe speeds than he is getting on most roadways today. It is all very well to argue that the motorist should not want more speed, but this argument presupposes that the author-

ities have been employed by the taxpayers to tell the taxpayers what they should want. Such a supposition would hardly hold water.

The argument is also advanced that, if safe roadway speeds are increased, this will only result in the motorist overdriving them, thus demonstrating that he wants still more speed, and that therefore roadways for higher speeds should not be built. If safe speeds are increased and then overdriven, they must be increased again until the point where the motorist feels that he cannot afford a higher speed. The fundamental point is that, under a democratic system of government, public servants must give the public what it wants. Some safety experts may not agree, and they would be perfectly within their constitutional rights to go out and "preach the gospel" of slower speeds. When they succeed in convincing the public that "their way" is right, then the time will have arrived when the engineer and the police and the educator should take this stand in response to public demand. Until that time is reached, the chief aim of public officials as far as transportation is concerned is to try their level best to give the public what it wants. At the present time what it wants appears to be a rather general increase in the time-saving value of the automobile. This, interpreted into action, means roadways designed to be safe at higher speeds than most of the ones which exist today.

Desirable Level of Speeds. The question naturally arises: What is the level of speeds desired by the motorist today? This level will vary in different geographical areas and under rural and urban conditions. It will also vary with different drivers, but roadways must be built for the majority of drivers, and the desire of this majority can be determined by speed analysis. Innumerable spot speed studies have been made. Caution is essential in interpreting these data, for often the speeds found reflect the limitations of the roadway rather than the desire of the motorist. Thus, speed studies designed to measure the motorist's desire must be made under conditions providing him with the opportunity to exercise his desire without fear of running into hazards or violating the law. The following are believed to represent the desire of the mode or majority driver, who may be termed the "design driver." These figures are entirely estimates. Their actual counterparts should be measured in each locality by speed counts supplemented by accurate measurements of motorist opinion.

1. In business or residential areas, except at blind corners or where there are pedestrians, it is estimated the design motorist will desire speeds above 20 or 25 miles per hour. He has been so spoiled by the comfort and ease of operation of the modern automobile that he will seldom drop below this speed because of an apparent hazard. It is quite possible

that any speed below this may be found impracticable to enforce—impracticable in terms of the number of officers and arrests it would require and of the adverse public relations which the enforcement of lower speeds would produce.

2. In residential areas where pedestrians and vehicular volumes are light, it is estimated that the motorist will want speeds above 30 to 35 miles per hour. Here the relative infrequency of the hazard will make him particularly impatient about submitting to more stringent regulations.

3. For through movements in built-up areas, the motorist will want speeds of 40 to 45 miles per hour if he is going a few miles, as in commuting or in going over to another part of the city. The motorist will not complain about a 20-mile-per-hour limit if he is not forced to hold himself down to this speed for any great distance. But if the purpose of his trip is interfered with too much by the time required in transit, he will either not take it or be tempted to drive faster to save time.

4. In rural areas in eastern or Atlantic Coast states from city to city, it is estimated that the motorist will desire to travel at speeds of 50 to 60 miles per hour. This means that once he leaves the city limits he has a range of 50 to 60 miles in one hour, 100 to 120 miles in two hours, and 150 to 180 miles in three hours.

5. In rural areas in the Middle West, it is estimated that the motorist will want speeds around 60 to 70 miles per hour.

6. In rural areas in the Southwest and Northwest, it is estimated that the motorist will want speeds of 70 to 80 miles per hour. This higher speed is somewhat conditioned by the fact that distances are greater and communities (origins and destinations) farther apart.

Again it should be pointed out that these figures are only estimated and that the issue as to whether the necessary roadways can be afforded has not been discussed. However, it is believed that speeds of 70 and 80 miles per hour are not at all prohibitive from the viewpoint of cost of operating cars. Ample numbers of cars equipped with overdrives operate at this speed at 15 to 17 miles to the gallon, which would be quite acceptable to most drivers wanting to go at this speed, at least unless the standard of living should drop considerably below its present level. The economic issue is therefore primarily concerned with the construction of the roadway itself.

It is highly important that attention be given to the speeds at which operators can drive safely at the design speed of the highway. This is a very nebulous question that cannot be answered factually because no adequate records are available. The fact that people have accidents at relatively high speed does not prove that they cannot drive safely at high speed

nearly so much as it proves that the road was not designed for that speed. On the basis of records, the great majority of accidents occur at stated speeds below 50 miles per hour. It is a question how many present motorists are capable of driving safely at 60, 70, and 80 miles per hour. There are undoubtedly many who cannot. This fact, however, should not be taken as conclusive proof that roadways should not be designed for 60 or 70 or 80 miles per hour. If many motorists can drive safely at that speed today, in spite of present roadways, others will learn to do so. The real issue is whether or not people desire to save time to that extent. If they do, then the proper roadways should be built and the proper training provided, up to the economic limit of the highway user. It should be emphasized that this does not mean up to the point where other forms of transportation, such as railroads or airplanes, are more economical. The motorist will probably be willing to pay much more than the most economical price if the degree of flexibility and service warrants the added expense and if he can afford it.

Speed Comparisons. If the foregoing speed figures are assumed to be reasonably in accordance with the desires of the motoring public, then it will be enlightening to compare these with the safe speeds provided for the motoring public today. The following offers such a comparison in miles per hour:

Estimated Desired Speed of Majority Motorist	Estimated Present Safe or Congested Speed (Best)	Difference
Miles per hour	*Miles per hour*	*Miles per hour*
A. Business and residential areas		
20–25	17	3–8
	(Business district, 10)	10–15
B. Residential areas, light traffic		
30–35	20–25	10
C. Through movements in urban areas		
40–45	30–35	10
D. Eastern and Atlantic Coast rural areas		
50–60	35	15–20
E. Middle West rural areas		
60–70	50	10–20
F. Southeastern and Northwest rural areas		
70–80	60	10–20

From this table it will be noted that there is an estimated average deficiency below the desired speed ranging from 3 to 20 miles per hour. This

deficiency rather naturally results in the overdriving of present facilities. These figures are estimated very broadly. The differential is considered conservative, for in many places the over-all desired speed will be 60 miles per hour, and owing to interruptions in highway speeds of built-up areas, the differential may well be 30 miles per hour. When any safety factor at all is considered these differences are magnified a great deal.

Utility of the Automobile. The various speeds which the motorist is estimated to desire in different parts of the country, under rural and urban conditions, and for different types of trips, having been discussed, it may be well to ask what this analysis means with regard to the utility of the automobile.

The automobile is fundamentally an instrument for conquering space and time. Its usefulness, and the degree to which it will be used, are measured primarily by its ability to do this. At the present time this tool is far ahead of the roadways provided for its use. It can go 60 or 70 miles per hour as a carrier of passengers at an acceptable cost. Yet present facilities under most circumstances permit the use of only a fraction of this potential. Thus it appears that the possibility of building new facilities which can absorb more of the automobile's potentialities is well worth considering. The following are of special interest:

1. The range in mileage of the use of a car is dependent upon the speed which it can make, because in general the length of trip depends upon the time the private driver has outside of business hours, or the time it is worth to a business in terms of perishable merchandise, capital tied up in transit, number of trucks required, and salary of personnel. If the automobile's range is increased, its utility is increased, and its efficient and economical use will be greater. If its range is decreased, its use will be decreased.

2. It may be confidently asserted that there is a very large marginal mileage of unexpended travel which would be utilized if the time range of available travel could be increased.

The prevailing length of trip today, as indicated by traffic studies, is apparently quite short. This, however, should not be taken as conclusive proof that the present average length of trip is what will prevail in the future or is that which is desired by the public. It is very likely that the shortness of the present average trip is conditioned to a great extent by the limitations on time opportunities imposed by the present facilities more than by the fundamental desire of the motorist or the ultimate optimum desirable economic use of the vehicle.

If this reasoning is sound, then as fast as the time zones of travel are increased by new construction the average length of trip will increase. If this is what is wanted by the private driver and by business, then it should be provided up to the economic limit. This comparison is somewhat parallel to the difference between what the present volume counts show and what the origin and destination counts show. Volume counts show where people go today, while origin and destination counts show where people want to go (though even this is under present time-zone conditions).

Examples of the increased volume and length of travel induced by the construction of new facilities which have enlarged time zones are numerous. In view of them, it would be advisable to refrain from concluding that the future of the automobile is restricted to comparatively short runs or that present usage has approached the saturation point.

The foregoing has been stated from the viewpoint of the utility of the automobile in reducing the time necessary to move persons and merchandise. All improvements in this utility must be checked against the cost of inefficiencies which result in accidents. It is quite possible that a sizable proportion of accidents can be prevented by new design. It naturally costs more through construction to make higher speeds safe. Thus the ultimate control will be economic. It is most important, however, that this stand be taken, rather than the stand that higher speeds should not be undertaken because they would cause more accidents. Such an attitude would stifle progress.

It should again be emphasized that none of the foregoing should be interpreted as recommending higher speeds on present roadways. In general the speeds of the upper 15 per cent of drivers should be reduced on most roadways. But this will not solve the problem of moving persons and merchandise more efficiently. The objective should still be to increase the safe rate of speed in accordance with economic justification, solely in terms of the ability of the operators of motor vehicles to pay.

Other Values of Time-Saving. It is hoped that the principle of advancing the utility of automotive transportation by the construction of superior designs for higher safe speeds has been established. Progress in this direction should be gradual and concentrated at those places where investments will bring the greatest returns. In general these locations will be in large metropolitan areas and between large centers of population. This will be found to be true chiefly because the higher volume of traffic will reduce the cost of construction per vehicle carried. However, expenditures for longer runs would probably be justified, once time zones had been sufficiently increased to give private car owners and business a sample of what can be done.

In considering the economic values of time-saving, it is important that

the effect of such saving upon other items than the cost of operating an automobile and building a roadway be taken into account. It is quite possible that such factors as the efficient planning of cities, the geographic cost of merchandise, the tax structure, and the stabilization of real-estate values may be dependent primarily upon the efficiency of transportation. If traffic improvements will help these, then such improvements are worth additional funds over and above the car and the roadway. With these basic potentialities in sight, the engineer should have a full realization of the significant part he can play in the social and economic life of the country. He should not be restrained by present "minuses" but should forge ahead to discover new improvements which may be of still broader social values.

PART TWO

ORGANIZATION AND ADMINISTRATION

CHAPTER VI

ORGANIZING FOR TRAFFIC

After the broad problem of automotive transportation has been briefly viewed and a realistic perspective obtained, the next step is to make a study of the processes by which something can be done about it. It is immediately apparent that little can be accomplished until proper organization and trained man-power are available.

The traffic problem is a public problem. In the long run it must be solved by public officials. Quasi-public organizations, traffic and safety organizations, commercial groups with a legitimate financial stake in the problem, technical consultants, public-spirited individuals, and others may help; but the task is of such magnitude that it cannot be handled except through government. Because the problem is relatively new, the existing set-up of some governments cannot deal with it efficiently. Hence a careful study must be made to determine what changes and adjustments in existing official agencies are necessary to meet this new problem in the best manner possible.

After such alterations are made, there still remains the equally important problem of competent man-power. As is true in any new field, efforts are first concentrated upon utilizing the existing personnel, especially those with sound training and experience in collateral fields. Unfortunately, the traffic problem is of such a different character that comparatively few of the older personnel are able to "carry over" and apply much of their collateral background. The next stage of development is to select and train existing or new personnel especially for this new field.

The carrying out of the traffic functions involves considerable growing pains of a public administration nature, as traffic activities cut across the functions of so many different departments and their subdivisions. New methods have had to be worked out to meet this difficulty. The point to bear in mind is that the development of sound organization, administration, and personnel is essential. The best techniques are practically useless if these are not provided.

There is definite need for consultants in the traffic field. They can be of valuable service in solving traffic problems where a full-time man is not

needed or cannot be afforded, in advising on special problems that do not warrant a permanent unit, and in assisting departments with the establishment or improvement of their organization and operation. No matter how good a department may be, there always will be times when a fresh point of view can assist in working out better methods. In addition, some consultants have an advantage in certain parts of the field for they have specialized in them and are familiar with special developments throughout the country.

The subjects of organization and administration are discussed from the point of view of rather well-developed traffic divisions. If the text were restricted to very small or minimum situations it would not be possible to show all the elements that are involved. Thus it must be kept in mind that while some of the recommendations may look like a large order it is not expected that they would be established immediately, but rather that each organization must start out in a small way and grow to its maximum development. All the functions and forms of organization shown are in use today in varying degrees of development.

Principle 15

THE TRAFFIC PROBLEM MUST BE TREATED SEPARATELY BY A SPECIFIC UNIT OF GOVERNMENT AND NOT SCATTERED AMONG LARGE NUMBERS OF DEPARTMENTS AND UNITS. Recognizing Mobility as a Function of Organized Society, Society Has Delegated the Responsibility to Certain Units of Government.

Society acts in an organized way to protect itself and make progress by delegating responsibility, as, for example, to the fire department for fire protection and to the police department for protection of life and property against crime. In like fashion, society must delegate traffic authority to government and similarly establish a special traffic unit to carry out the essential activities. This takes such forms as the Federal Public Roads Administration and the Motor Carrier Division of the Interstate Commerce Commission; state highway departments, state traffic engineering offices, motor-vehicle departments, highway patrols, city traffic engineers, traffic divisions of police departments, and traffic commissions.

Importance of Sound Traffic Organization

No basic social problem can be successfully met until governmental functions for it have been properly organized. The best technicians and plans cannot produce action until an effective structure has been erected as a basis for operations under the existing form of government.

State Government

State organization for traffic normally requires eight traffic units. The agencies and functions which should be provided for in every state are as follows:

1. **A Traffic Engineering Division in the Highway Department.** This division deals with signs, signals, markings, islands, and traffic design. It deals with the traffic problem from the surface up. It should include the gathering of traffic facts. It may include planning activities from the roadway out to its adjacent land, if a state planning board is not maintained. All these activities deal principally with the functions of traffic movement rather than the details of physical design, construction and maintenance. This division should serve the police by interpreting technical data and advising on selective enforcement. It should

also work closely with the design division on matters of geometric road design.

2. **A Highway Planning Survey.** This fact-finding agency usually deals with the broad facts behind all the operations of a highway department. The Public Roads Administration deserves great credit for the stimulation and assistance it has given states in searching more and more deeply into the controlling facts behind sound highway planning. The survey should concentrate on financial and physical inventories, leaving gathering of traffic facts to the traffic engineering division. This plan of consolidation appears to be gaining favor in many states.

3. **A State Planning Board.** This deals with the broader aspects of the movement of persons and commodities. Its land use zoning activities are most commonly associated with traffic control. It makes such surveys as land use, recreational areas, industry, forestry, and agriculture. It should also make special studies leading to a coordinated transportation system.

4. **A Traffic Division of a State Police or a Highway Patrol.** This unit is needed to enforce all state laws affecting traffic.

5. **A Motor-Vehicle Department.** This administers the registration of automobiles and the licensing of drivers.

6. **A Traffic Safety Unit within the State Department of Education.** This would handle traffic safety education in elementary and high schools.

7. **A State Traffic Commission Composed of the Heads of All Traffic Units.** The function of this is to coordinate the activities of all units into a unified plan. It also is a clearing house on plans and serves to keep each unit within the bounds of its own traffic function. This would not be needed where one state commission administers all these functions.

8. **A State Safety Council.** This unit is to mobilize business and private citizens behind the sound plans of the commission and each traffic unit.

City Government

City organization for traffic normally requires six traffic units. The six agencies and traffic control functions which must be provided for in every city are as follows:

1. A city traffic engineering division located in an engineering department, or established as a separate traffic commission.
2. A traffic division in the city police department.

3. A city planning board.
4. A traffic safety unit in the board of education.
5. A city traffic commission to coordinate the program.
6. A safety council to sell the program.

In cities of more than 100,000 population these units would be separate. In cities of 50,000, traffic engineering and planning might be combined into a single division. In smaller cities the safety council might become a division of the chamber of commerce; the traffic division of a police department might be only one man. The separation of the function is more important than the number of men assigned to it. Their functions are the same as those in a state. A community too small to afford a full-time traffic engineer, would have to employ some of the excellent traffic consultants available, or receive its technical traffic engineering services from the state traffic engineering division.

Thus, summarizing the organization of states and cities: traffic engineering divisions, traffic divisions of police departments for enforcement, motor-vehicle departments for registration and license, educational units for schools, traffic commissions for coordination, and safety councils for molding public opinion in favor of governmental plans must be established. In both states and cities the separate traffic units should be sufficiently high on the organization chart to have authority to do the job.

Coordination through Traffic Commission

The coordination of all traffic units is especially important. Unfortunately, owing primarily to the rapidity with which the problem has developed and to the differences in the background of engineers and enforcement officials, this active day-by-day cooperation has not advanced so rapidly as some of the techniques.

From the engineering point of view, police cooperation is most critically needed in regard to speed and to signs, signals, and markings. Until roadways can be changed to permit higher safe speeds, the engineer must rely upon the enforcement officers to keep motorists within the present safe speed. When any new roadway is opened for travel, the design speed must be taught to the motorists and enforced by the police. In each case a special conference should be held to decide on the educational and enforcement policy.

In like fashion, all restrictive signs, signals, and markings hinge on education and enforcement for their successful operation. Unfortunately, far too many signs today are rendered almost completely ineffectual for

the reason that they are not obeyed. As a matter of fact, there is serious question about the merits of putting up more control signs unless the police can guarantee obedience. Quite probably, too, in many parts of the country it would be sound policy to remove a very large number of obsolete or inadequate signs. Lack of observance of existing signs definitely reduces the value of new ones.

The engineering department should erect no new sign without first having a conference with the police to determine whether or not they are able to assign a man specifically to enforce obedience of the additional sign at least until the normal enforcement pressure will hold obedience at an acceptable level. If the police cannot do this, the installation of the sign should be postponed until they can.

The same principle applies not only to signs and signals but also to all new construction, new devices, or changes which the highway department may make.

It is obvious from the number of occasions on which cooperation is required during a given year that some governmental mechanism is essential to channelize and formalize the required cooperation. This is the function of the traffic commission representing all traffic units. This organization should have monthly or weekly meetings, determine policies, and deal with major cases.

To be completely effective, this cooperation must be carried right out to the districts, where there should be close day-by-day cooperation between the district traffic engineer and the captain or lieutenant in charge of the nearest police or patrol troop or unit. These men will be much more familiar with the local conditions and can work out the great bulk of detailed cases under the policy of the commission without having to have detailed authority through a commission meeting.

The same policy should be followed with local police who have major jurisdiction over considerable mileage of state highways or state routes.

The state traffic engineer is also greatly concerned with the educational efforts of the motor-vehicle department. It is greatly to his advantage to have signs, signals, and markings, and standard designs taught to the motorists through the literature given in connection with their examinations and annually with their license plates.

Consistent progress on traffic matters cannot be made until government is properly organized. Outstanding men with particularly aggressive personalities may do a good job under poor organization, but when they are succeeded by average men, conditions will become worse.

It is hoped that the Public Roads Administration will follow up the ex-

cellent work of its state cooperation on highway planning surveys and functionalize its own organization toward traffic engineering even more than it has, to the end that through its districts it may advise all highway departments in this new branch of highway engineering.

All state highway departments should eventually follow the definite trend of establishing a traffic engineering division. The early formalization of this function will do more in the long run to advance transportation than almost anything. In order to carry out its function of providing a complete highway system, it will have to "service" most of the smaller communities whose population cannot support a separate technician on traffic matters.

Every city of more than 100,000 population should eventually have a traffic engineering division. Many cities of 50,000 can justify one if they combine with it the functions of planning.

In large cities there appear to be two other organizational problems which have not as yet been met. The first is to transfer the traffic engineering functions of park areas, authorities, and commissions to one centralized traffic engineering division. The second is the consolidation of all traffic engineering functions within a metropolitan area to one centralized unit. It is in these areas that the greatest traffic pressure exists today. Under these circumstances, a diversification among several agencies of problems which are identical to most citizens and visitors is particularly inefficient.

TRAFFIC ENGINEERING FUNCTIONS ARE SPECIFIC: These Functions Deal with Mechanical Control, Geometric Design, Planning, Surveys and Collateral Subjects. The Earlier Trend Was toward Detailed Operations. This Is Now Shifting to the Broader Aspects of Transportation.

The accompanying table is based on data received from the present leading traffic engineering offices throughout the country. Attention is directed to the fact that the distribution of time does not refer to that of the director of the traffic division or to the traffic engineer. It refers to the total man-hours of the whole department. Even after the time of the administrator is taken out it might appear that the operations of the traffic engineers are primarily concerned with the mechanical details of signs, signals, markings, and islands, and not with the broader aspects. This, however, must be recognized as the situation at present, a situation representing but the first stage of this new field of traffic engineering—a stage in which these mechanical details are highly important.

In the long run these details control the safety and efficiency of any given intersection or short stretch of roadway, and they will continue to do so until new roadways are built that will remove the necessity for them. Thus the traffic engineer has quite properly elected to operate on a basis of "first things come first" and has set as his first objective the remedial measures for the sick roadways of today. It is obviously more efficient to provide these "crutches" in order to get the optimum use out of our present roadways than to attempt to replace all inadequate roads immediately.

Once the traffic engineer has the mechanical control problem on a routine operating basis, he will proceed to the objectives kept in mind since the beginning.

The first of these will be to correct existing bottlenecks, hazardous intersections, and improperly designed curves, and hills.

The second will be the development of bypasses and limited ways at points which represent the most inefficient spots in the highways system today.

The third will be the development of limited ways with no inherent faults and sufficient insulation to guarantee operating efficiency for many years to come.

The fourth will be the projection of traffic facilities, including parking, to serve the needs of the future.

The fifth will be a detailed study of highway economics to show how a

traffic budget may be balanced and projected to yield a public profit on future investments.

Naturally these stages will never be completely separate and distinct but will overlap, the difference in effort concentration being determined by the urgency of the first-things-first factor.

It should be noted that the initial trend of traffic engineering will be toward what used to be known as physical planning. It is quite possible that certain aspects of the planning function must be adopted by the city or state traffic engineer, who might even change his title to traffic planner or become the director of traffic engineering and planning, as he is now in the city of Schenectady, New York. There is considerable merit to this potential combination. Some of the functions of planning cannot be separated from traffic engineering, and no large plan will be successful unless each of its parts will work. These parts, such as intersections, are specific items that the traffic engineer is already repairing. The traffic engineer cannot win if poor planning keeps bequeathing him more detailed problems faster than he can handle them. Moreover, the planning function has suffered because it has not been an operating unit of the government. Being merely a board or commission, frequently unpaid, and depending for its existence upon a "donation budget" each year, the planning commission could too easily be wiped out by an economy wave or a political turnover, chiefly because it did not have any operating or maintenance function which had to be preserved to permit the daily use of the highway. Likewise, its reputation has suffered among professional traffic engineers because the plans were sometimes considered theoretical and impractical where they did not include operating detail. This produced a competitive situation in which both the traffic engineer and the planning commission suffered. Many traffic experts feel that the virility which goes with a large operating budget will assist the planning function by coordination. As a practical matter the development of the traffic problem has made the work of the planner much more important, and some of the inventions of the traffic engineer have placed new tools at the planner's disposal.

The next probable trend of traffic engineering will lie in the direction of economics. The words economics and planning have been gravitating toward each other for some time, and the term "economic planner" has come into being. The economics of highway construction has received a good deal of attention recently, but thus far comparatively little is known about the economics of free-wheel transportation in terms of applying the losses of accidents and congestion to remedial measures which would relieve them and save money. It seems inefficient and retrogressive to be paying out the equivalent of many improvements which could be had, without enjoying

the benefits of them. Facts on this matter are woefully lacking, and millions of dollars have been spent to find out our present volumes of traffic and their classification, and the origin and destination of present movements. Comparatively little is known of the future movements based on business, pleasure, and educational demands; of induced traffic, including millions of potential but unexpended miles of travel held back by lack of facilities; or of the present enormous losses of congestion.

PRESENT DISTRIBUTION OF TYPICAL TRAFFIC ENGINEERING STAFF ACTIVITIES

Percentage figures represent estimates based on *present* operations.

The percentages assigned to each function are those of the total man-hours of all staff members. The time of the traffic engineer will be concentrated on the broader and more fundamental units of surveys, islands, intersection, redesign, roadway design, and planning.

General Traffic Engineering—90%

70% Mechanical control and parking most common activity of traffic engineer (should be reduced to about 35%)

1. Signs and regulations
2. Markings
3. Signals
4. Islands and intersection redesign
5. Street and highway illumination
6. Terminal facilities—loading and parking regulations

10% Design and planning broader fundamentals less frequently in daily use (should be increased to about 35%)

7. Roadway design
8. Traffic planning—through ways, one-way streets, major street systems, zoning

5% Important procedures used in all traffic engineering assignments (should be increased to about 15%)

9. Traffic surveys
10. Accident records
11. Administration and organization
12. Economics of free-wheel transportation

5% Collateral subjects having important bearing on work of traffic engineer

Education

13. Public education in support of sound traffic plans and financing
14. Public relations

Enforcement

15. Enforcement of speed, signs, signals, markings, turnings, passing, etc.

Collateral Activities of Which the Traffic Engineer Should Have Some Knowledge—10%

5% Traffic planning (should be at least 10%)

16. Land use
17. Housing
18. Transportation systems
19. Roadside parks
20. Architecture and civic art
21. Major street systems
22. Zoning
23. Roadside beautification

23a. Recreation areas

2% Roadway construction

24. Right of way
25. Soil mechanics
26. Concrete, macadam, etc.
27. Bridges
28. Maintenance
29. Surveys

2% Legislation

0.5% Economic planning

30. Transportation cost
31. Roadway cost
32. Taxation use

0.5% Political science

33. Public administration
34. Organization
35. Objective criteria
36. Tax structure

NOTE: The above functions are carried out by surveys, research, standards, installations, operations, and maintenance.

The "forgotten man" among traffic surveys is the speed and delay study, which, interpreted through time zones, can measure the real service value of roadways, namely, that which is measured in terms of time-savings. This is one of the most productive fields of research that should be undertaken. The traffic engineer is the technician who has the background to apply economics based on the dynamics of movement rather than the statics of concrete, macadam, steel, soil mechanics or right-of-way acquisition. The field of economics has suffered for lack of the engineer's environment, and he has suffered for failure to evaluate the services which it is his function to perform.

It appears logical to many members of the profession that in the long run the highway department will change its present form and become in fact an operations department whose function would be to move traffic, not just to build structures. In this transition the traffic engineer must play a very important part; his work would be integrated with planning and economics and he might conceivably, by a gradual evolution, turn out to head the operations department of a state in all automotive transportation matters. Such development, of course, is contingent upon the regular retirements and personnel turnover normally expected in all departments.

The traffic engineering job should be thought of along the general lines that maintenance work requires engineers trained in maintenance, construction work requires engineers trained in construction, and in like manner the operation of the system requires men trained in that phase of the work. Similarly, administrative work in an engineering division should be done by engineers who have had administrative training. Thus professionals in this field should think of themselves first of all as engineers, and secondly as having had specialized training in one phase. They are really no different, fundamentally, from any other engineer in the department. Only in this fashion will traffic engineering be fully and completely accepted by the older branches of engineering. And likewise, this is the only way that traffic engineering administration can progress—for administration is administration, whether it be applied to construction, maintenance, or traffic engineering.

THE TRAFFIC ENGINEERING ORGANIZATION MUST BE GIVEN ADEQUATE IDENTITY AND AUTHORITY: It is Essential for the Traffic Engineering Organization To Be Established as a Separate Unit and Not as a Small Portion of Some Unit of Government Having Numerous Other Functions. In a City It Should Report Directly to the Head of an Engineering Department, City Engineer, or Mayor. In a State It Should Report to the Chief Engineer of the Highway Department.

The controlling reasons for giving traffic engineering organizations adequate identity and authority are as follows:

1. Scattered Functions Inefficient. Traffic control cannot be effective if its functions are scattered throughout several departments or among several units of one department. The engineering control of traffic is believed to be sufficiently important to warrant the establishment of a separate and distinct unit devoted solely to this function.

2. Authority Must Be Centralized. Nothing is more confusing or can delay progress more than uncertainty as to whose responsibility a traffic job is. When this condition prevails the average traffic employee is afraid to act for fear of stepping on someone else's toes. Conflicts with authorities of other departments create wasteful competition. Clear-cut authority permits direct, quick action.

3. Responsibility Must Be Centralized. If it is no one person's job, it is nobody's, and if the job does not go well each person will pass it on to the next, and thus efficiency cannot be measured and maximum progress cannot be made.

4. A Separate Traffic Budget Is Essential. An organization cannot have maximum self-respect if forced to live off the funds of any other unit of the department. Many departments have found that, although it was impossible to get additional badly needed funds for their activities, as the public could not understand the complications of the allotment of funds, the funds could be more easily obtained if a separate traffic budget was established for traffic engineering, because its functions could be made readily understandable. In addition, it is impossible to maintain efficient budgetary control unless the funds for traffic engineering functions are set up as a separate unit.

5. Public-Relations Values. A traffic engineering division has a higher public-relations value than most units. Motorists usually judge a department by things they can see. Unfortunately, they cannot see the good work which goes into soil mechanics, foundations, broad plans, concrete, or

macadam. But they do see the signs, signals, markings, islands, and streamline design, all of which are the daily job of the traffic engineer. Since the creation of a separate unit will improve traffic movement, the whole department stands to gain by it.

6. Pride in Organization. Pride in one's work helps to produce craftsmen and good technicians. If a man feels that he is part of a particular unit, he can be proud of his work and of his outfit. If he is merely a small cog and is performing a task which is just a part of some function scattered throughout the department, he will not feel this way about it.

7. Proportionate Attention. No new field has progressed very far, or has been given the attention it deserves, until it has been dignified by the establishment of a separate department. This serves to focus public as well as official attention upon the problem. It permits adequate credit to be given for accomplishments. It also makes it possible for the head of the department to attend staff meetings and to deal with other divisions on an equal basis.

8. Expert Knowledge. Specialization aims to produce increased knowledge and competency on any particular subject. The older fields of project, construction, structural design, bridge, and maintenance have grown so that it is beyond the average mind to know all about any one of these and to learn much about the newer field of traffic engineering. It is equally true that the field of traffic engineering has grown so fast that it will require the full time of any man to get and stay up-to-date in this subject. Furthermore, it will usually be found that the best technician in any field is one who selects it for his profession and receives special training for it. Such a man cannot be attracted unless the field and the position are set up on a professional basis which carries the specific function.

9. Economic Savings. A separate traffic engineering division should be able to carry out traffic functions at a saving because of the avoidance of overlapping and duplication of effort.

The points cited show the importance of establishing traffic divisions with separate identity and authority. This should be done by administrative order or legislative act.

The establishment of such a unit may look easy on paper. As a practical matter, it will be hard to accomplish for the following reasons:

1. The older divisions which have in the past carried out some of the traffic functions will naturally prefer to keep the authority, the men, and the budget.

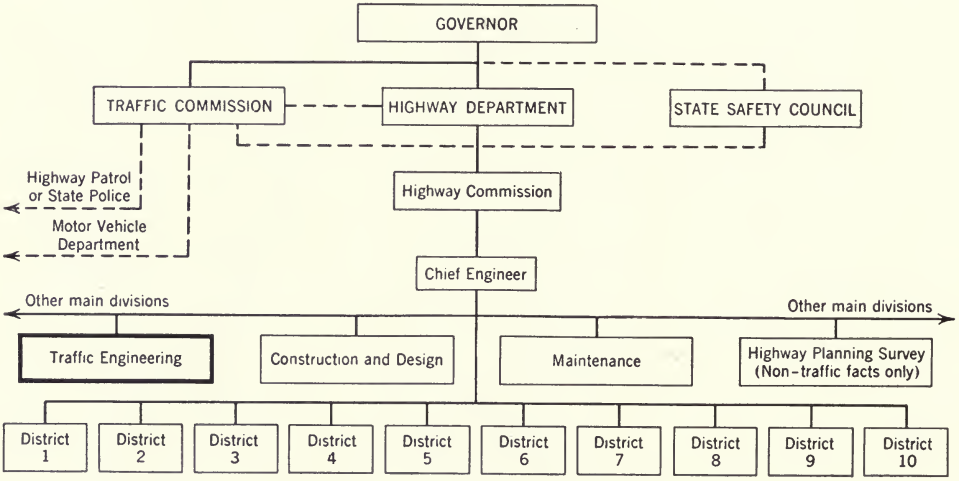
2. So many scattered functions are involved that it will be hard to gather up the loose ends.

3. So much custom, habit, and routine must be changed that many employees will be considerably upset.

It is therefore essential that a thoroughly official and authoritative announcement be made when a separate traffic division is set up. This should be in the form of a regular bulletin or communication addressed to every employee affected. It should be particularly specific in respect to authorities, duties, and overlapping of activities. It should be signed by the head of the department. It would be helpful if the head also made a personal announcement of it before a regular staff meeting.

The progress on any such reorganization for traffic control should be followed up each month for at least one year until it was found to be working smoothly.

SAMPLE LOCATION OF A TRAFFIC ENGINEERING DEPARTMENT IN A STATE HIGHWAY DEPARTMENT



Principle 18

THE LOCATION OF A TRAFFIC ENGINEERING DIVISION IS IMPORTANT: It Is Particularly Important That the Traffic Engineering Division Be Located in a Department Which Represents a Functionally Sympathetic Background and Where Its Findings May Have a Maximum of Directional Control.

The choice of where the traffic engineering division should be located is an important but difficult one. It may be assumed that the division will reflect the environment of its home. Since the attack on the problem is an engineering one, the only satisfactory answer is to set up the traffic engineering division either as a completely separate unit, not under any department, or to place it in an engineering department. This reasoning leads to the conclusion that it should not be placed in a department of public safety, a motor-vehicle department, or a police department. All these are chiefly concerned with safety. Safety is important, but it is only the first half of the whole transportation problem of which congestion is the second and equally important part. These departments will also not make a good home for traffic engineering because they are not manned by engineers and thus will not adopt the attitude of the engineer.

In a city a separate traffic commission can be established as it has been in Boston. If this is not done, then the traffic division should be placed as a main unit of an engineering department. To be most effective the traffic head should report directly to the city engineer or the head of the main engineering department. If the traffic engineering division is placed lower than this on the organization chart it will not have a voice at the top of government and, therefore, will not be able to assume leadership in traffic matters.

State Traffic Engineering. In state government the logical location for a traffic engineering division is in the state highway department. This is the basic engineering department of the state; it is the department which builds and maintains the roads. As has been stated above, the state motor vehicle or state police departments are locations where the traffic engineering division should not be placed. Their governmental functions of enforcement and license-registration administration are quite separate from the basic functions of traffic engineering. Furthermore, it has frequently been observed that one department of a state is averse to taking orders from another department. Since the activities of a state highway department include many basic elements of traffic engineering, it is essential that the traffic engineer be located there.

Within the state highway department it is essential that the traffic engineering division be placed on a par with the other basic divisions, such as project, construction, and maintenance. The reasons for this are: First, as traffic engineering activities cut across almost all other departments, it can hardly be placed under one. Second, the fundamental importance of traffic engineering warrants its rank as a division. If it is subjugated to maintenance, for example, it will not have sufficient prestige with the other divisions to demand respect or command attention and get action. Furthermore, it will not rate with the districts where much of its important work must be done. Again, it will not be heard at the top of the department through lack of personal representation at staff meetings, and hence its budget may suffer.

City Traffic Engineering. The same logic applies to cities, where traffic engineering belongs in an engineering department. The accomplishment of this in a city will be more difficult than in a state because before the development of the profession of traffic engineering some of the minor mechanical control functions of traffic engineering such as signs, signals, and markings were handled by police departments. Even though the police were not trained engineers, electricians, painters, or constructors, they have been reluctant to give up this function which has suddenly become so popular. Some traffic engineering divisions are successfully operating as part of police departments, but this should be taken as a tribute to the traffic-mindedness and progressiveness of the chief of police rather than as proof that the division is properly located. Any governmental plan which relies for its successful operation upon the fortuitous attitude of a particular office holder, or upon his accidental cooperation with other department heads who happen to be his friends, is bound to fail as soon as a different type of man heads the department. The same arguments hold almost as strongly in the few cases where traffic engineering divisions are located in departments of public safety.

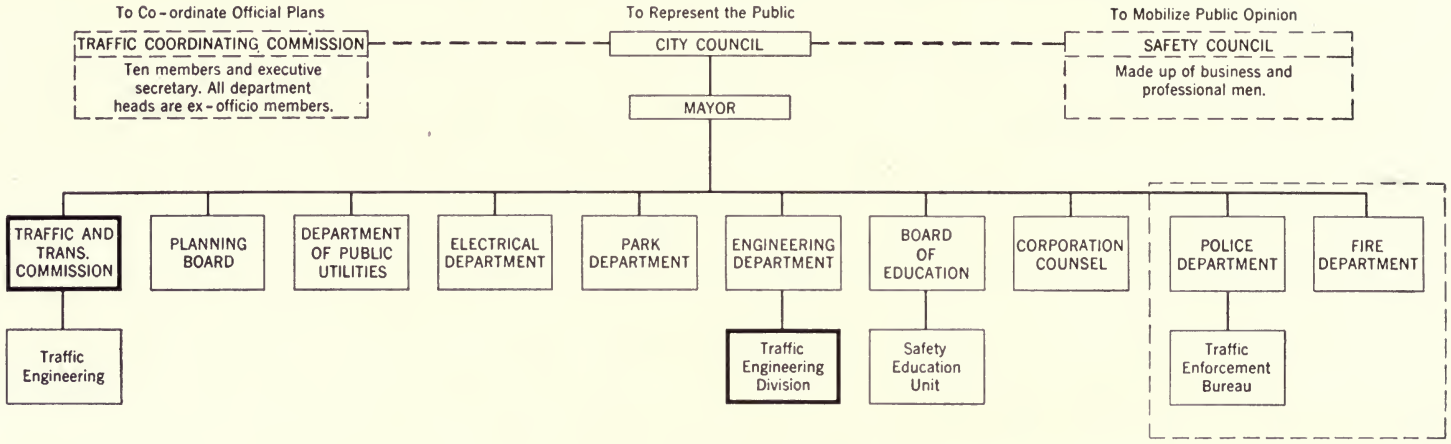
In deciding where to place the traffic engineering division in city governments, many points are to be considered. Among the major ones are the following:

(*a*) It must be high enough on the organization chart to obtain the authority and budget which the important field of transportation warrants.

(*b*) It should be on a level with or a part of those existing departments which have operations of most importance to traffic engineering and to transportation.

From past experience, four choices of location have proved practical and workable:

SAMPLE LOCATION OF A TRAFFIC ENGINEERING DEPARTMENT IN A CITY



SUGGESTED TITLES

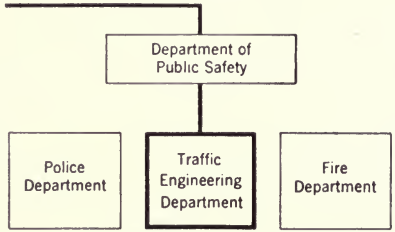
1. Transportation Commission.
2. Division of Traffic Engineering and Planning.
3. Traffic Engineering Division.
4. Division of Traffic and Safety.

A. Director
B. Assistant Director
C. Traffic Engineer
D. Assistant Traffic Engineer

FUNCTIONAL PROCEDURE

1. Plans formulated by Traffic Engineering Division.
2. These plans co-ordinated with other departments by Traffic Commission.
3. Mayor and Council agree on refined plans.
4. Safety Council mobilizes Public Opinion in favor of plans developed by Public Officials.

ALTERNATE ORGANIZATION



1. A traffic commission having full authority on all traffic matters and being on a level with fire, police, and street departments. This has the greatest potential authority and budget. It would be the hardest to obtain, for it must remove authority from any other units and in many states will require a legislative act because of charter or other legal restrictions.

2. A traffic division in the largest engineering bureau or division. It is important that the traffic division report directly to the head of the engineering bureau or to the city engineer. If it is placed lower on the organization chart and must report through some other unit, it cannot operate with maximum efficiency. In an engineering department, the traffic engineering division would be a part of that engineering agency which builds the streets and in some cases handles the electrical as well as engineering work.

3. A traffic division in the department of public safety, placed on a par with the police and fire departments. This would provide maximum coordination with the enforcement agency but, on the other hand, would make coordination with the engineering department much more difficult. Though police cooperation is important, it deals primarily with the accident half of the problem and has relatively little to do with the congestion half of the problem, with which the city engineering department is much concerned. Furthermore, the public safety department has almost no interest in planning matters, and this location would almost preclude traffic engineering from swinging more and more toward planning, as it should. Thus, the location of the traffic engineering division in the department of public safety would help accident-prevention operations but would be unfavorable on the side of congestion and planning.

4. A traffic division in the police department. This location presents many difficulties. It places the unit too far down in the structure of government to be effective. It mixes engineers with police officers under conditions in which their differences in background, leading to differences of opinion, may cause constant friction and retard progress. A traffic engineer reporting through a chief of police would have more difficulty in getting cooperation from the engineering department because of the natural differences of opinion of the two departments. The civil-service classification of officers and engineers might also cause more confusion than the classification of traffic engineers with other engineers in an engineering department.

Under some conditions, as where the department of public safety or the police department is particularly strong, there will be a temptation to place the traffic engineer in either, as a political expedient. This point could be argued as being better than delaying the establishment of a traffic engineering division elsewhere if it would require a long period of education to induce the police to give up traffic signals, signs, and pavement marking.

In special cases such a procedure may be warranted, but there is a strong possibility that it might have the effect of anchoring traffic functions in the police or public safety department. If the police thus do a better job on the engineering phases of traffic regulation, this will probably result in making it much harder to move the traffic functions to an engineering department at a later date.

CREATION OF A TRAFFIC ENGINEERING DIVISION DOES NOT NECESSARILY INVOLVE ADDITIONAL COST. It Should Be Strongly Pointed out that the Creation of a New Traffic Engineering Division Does Not Necessitate Additional Funds unless Additional Traffic Work, Not Now Being Done, Is to Be Undertaken. It Merely Means that the Men in Scattered Departments Who Have Been Carrying on Some of the Phases of Traffic Engineering Are Transferred to One Central Unit. As a Matter of Fact, This Should Bring about the Usual Economies Which Accrue through Removing Overlapping Functions and Competitive Expenditures.

Some administrators have had a tendency to hesitate in creating a full-fledged traffic engineering division in the belief that it would entail additional cost. As a matter of fact, the actual creation of the division need not cost any money at all. Fundamentally, it means merely an administrative order consolidating all traffic engineering functions, bringing together the men who have been carrying out these functions, and changing the bookkeeping system so that all funds utilized for traffic engineering are consolidated.

This fear of additional cost is sometimes increased during a year when the political leader has come out for economy. Under these conditions, the administrator may be afraid that the creation of a new organization may appear to the public to be expansion and thus an expenditure of more money in the face of a policy of retrenchment. If the political situation is as critical as that, then the administration might be wise to take action strictly within the department, accomplishing the reorganization in fact, even though no public announcement is made of it.

It is possible, however, to explain the new division to the public as not representing an extravagant expansion. Besides, there are so many definite public-relations and political values in traffic engineering work that it would seem foolish for any administrator to fail to take advantage of the creation of such a division. It has been the experience of departments which have proceeded with the development of a complete traffic engineering division that it is beneficial to spend a larger proportion of the total budget for this type of operational activity, which all motorists can see and which is thus much more easily justified.

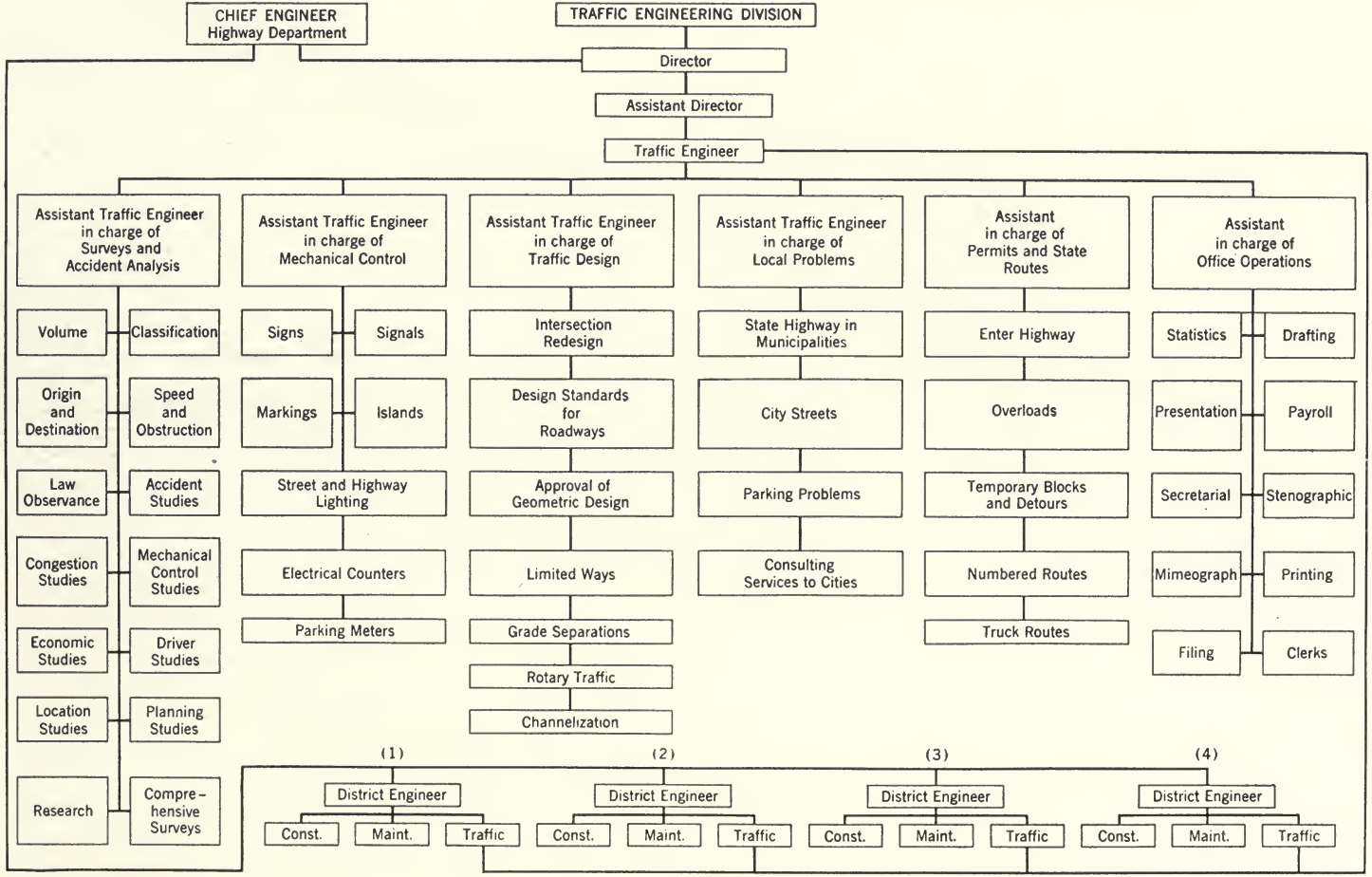
The cost of traffic engineering is a perfect example of the importance of judging not merely by the size of the budget but rather by the return on each dollar invested in each of the other divisions of the highway depart-

ment. Once this investment has been carefully evaluated, it is probable that the transportation needs of the future will bring adequate amounts for traffic engineering.

If the functions of traffic engineering are merely transferred and no new ones added, the consolidation should not require additional funds. Even if new functions are believed to be essential, this does not necessarily require new funds. If new funds are not available, the merits of the new functions must be weighed against other, existing operations. If the new functions are more important, then all that is required would be a reallocation of existing funds through changing the budget by administrative order. This process is repeated every year, since it is unlikely that each unit of the department will warrant the same proportion of funds every year. Those that become more important must receive a larger proportion of the funds at the expense of those that have become less important.

SAMPLE ORGANIZATION OF STATE TRAFFIC ENGINEERING DIVISION

(Fully developed for a large state)



Principle 20

THE INTERNAL ORGANIZATION OF A TRAFFIC ENGINEERING AND PLANNING DIVISION WITHIN A STATE HIGHWAY DEPARTMENT SHOULD BE FUNCTIONAL. Because of the Newness of Traffic Engineering It Is Particularly Important that the Form of the Organization Be Carefully Established to Carry out All the Traffic Engineering Functions.

In order to determine the best way to fit this new unit into the highway department it is necessary to study the functional history of departmental changes which have been made to meet new conditions. The historical development may be divided into three stages as follows:

Construction

During the first stage most of the efforts of the department were centered upon construction. This coincided with the so-called good roads movement to get the farmer out of the mud through building farm-to-market roads. At this time the entire highway department was practically a construction department.

Maintenance

With the primary system well under way, a maintenance problem of sufficient importance arose to warrant a separate division or unit. In some states this has grown to be the leading unit. This stage provided the highway department with two main divisions or units, construction and maintenance.

Traffic Engineering and Planning

The "automotive revolution," by producing high speed and heavy volumes, completely changed the complexion of the traffic problem. The structural problem of holding something up (from the subgrade to the surface) was superseded by the problem of operations or control (from the surface up). The structural problem of holding something up merely provided a foundation upon which to erect an operating structure. In other words, the operating problem had outrun, in importance, the construction problem, just as it did in railroading. The highway engineers had done a magnificent job in building a highway system. Nevertheless, the nature of the problem changed so fast that accidents and congestion were inevitable

until brand-new surveys, analyses, and techniques could be developed. Since there could be practically no carry-over from a background of experience dealing almost entirely with physical elements to one in which the operating characteristics of the drivers were the controlling factor, a new science had to be developed and a new type of engineer trained. This required of the highway department three main functional activities: (1) providing facilities, (2) maintaining them, and (3) operating them.

As previously noted, it is possible that this new unit of traffic engineering whose field is transportation and far broader than construction or maintenance, may include the physical aspects of planning and be known as traffic engineering planning, or transportation. It is not beyond the realm of possibility that it might in twenty years become the chief functional motive and, with maintenance as a routine operation and construction slowly changing to reconstruction and superconstruction, be the controlling mechanism of the entire highway department.

The relationship between planning, traffic engineering, and design is very important. Planning studies the traffic problem from the point of view of contiguous land uses to the roadway itself. It shows the effect of this adjacent land upon the roadway itself. Traffic engineering takes the plan from there on and states the geometric design necessary to meet the demands of the lands served by streets and highways. Design endeavors to incorporate those traffic principles into physical structures in accordance with the topography and nature of the land upon which the roadway is to be placed. Construction works out necessary materials and their relationship to strength and use and builds a facility. Maintenance attempts to keep the structure at its original level of physical efficiency. During all this, the traffic engineer consults and advises with each. He makes traffic plans, works out traffic design, and arranges for mechanical control.

Inasmuch as planning and traffic engineering cannot be separated, it is probable that the survey or fact-finding unit of traffic engineering may eventually include most traffic data operations. The development of highway planning and roadside beautification units are examples of other new units required to handle new activities. Coordination of functions will eventually require the establishment of a traffic commission representing the major departments and having controlling powers.

The Highway Planning Surveys established and operated concurrently by the United States Public Roads Administration and each state highway department represent one of the most progressive steps taken toward improving automotive transportation in the last twenty-five years. While the gathering of facts by highway departments had been going on for many years and fact-finding could hardly be said to be new, great credit is deserved

by those responsible for the creation of the highway planning surveys because it formalized the process, increased the breadth of surveys tremendously, and fostered planning.

This expanded operation is now well under way, and its value has received general recognition. As it has matured as a function there naturally have arisen questions as to how it can best be fitted into the highway organization as a permanent part. The word "survey" does not imply to many engineers a permanent operation, nor does it sound like the title of a subdivision of a highway department. Originally in many state highway organization charts the highway planning survey was shown in a box connected by dotted lines to the box indicating the chief engineer or state highway engineer. This location, and the dotted line, did not place the survey on the same footing as the regular divisions, such as construction, maintenance, and traffic engineering. Rather it placed it in an advisory capacity. In a few states the highway planning survey was placed under the traffic engineering division, which had for many years been conducting traffic surveys of a similar though less exhaustive nature.

The introduction of a new function into an old organization is usually determined by (*a*) the similarity of its work to an existing subdivision, (*b*) the desirability of guaranteeing its coordination with an important collateral function by placing the two in the same division, (*c*) the proportion of the new function's activities which would be used by each of the older divisions, and (*d*) the number of existing divisions.

Relationship between Planning and Traffic Engineering. If the highway planning survey were sufficiently close to any existing division it might be advisable to bring the two together and consolidate both functions by creating an enlarged division with a broader title and more authority. If the differences are sufficiently great, the two functions should be retained as separate divisions of the highway department.

The steps taken by the American Association of State Highway Officials regarding traffic appear to have a bearing on the question under discussion. Recognizing the importance of accidents and congestion, the association first established as one of its committees on administration the Committee on Traffic Control. Later, possibly in recognition of the growing importance of the profession of traffic engineering, the association changed the name to Committee on Traffic Engineering. The next step taken by the association has an important bearing on highway planning surveys. The association changed the name to Committee on Planning and Traffic Engineering. It is understood that this last change was made to give the personnel of highway planning surveys a voice in association committee work, to bring the two functions closer together, and to give added emphasis to planning.

The association also raised the status of the committee by making it one of the committees on standards.

During the last ten years the field of traffic engineering has been constantly broadening—from surveys, signs, signals, and markings to channelization, design, planning, and economics. Obviously, transportation cannot be permanently improved by the traffic engineer without his applying a great many techniques which could come under the very broad heading of planning. Hence the trend generally appears to be to put planning and traffic engineering together in the interest of transportation.

Traffic Facts Needed by Traffic Engineers. It would appear undesirable to take fact-finding away from the traffic engineering division. The unit that uses the facts is usually in a superior position to know what kind of facts are needed; how, where, and when they should be collected; and how they should be tabulated and presented. If this division is forced to rely upon another agency for its information, its operations will not be so successful. Furthermore, to have two agencies collecting similar information would constitute serious overlapping.

Traffic Engineers Need More Survey Information Than Other Divisions. If the highway planning survey was to be combined with any other unit of the highway department in making a permanent location for it, it would be logical to determine which existing unit is in the position to use most of the facts obtained.

If the words traffic engineering are given their broad meaning, then a division called traffic engineering, because it deals with the movement of vehicles rather than the structural process of supporting the vehicle, will require more facts and broader facts than any other single existing subdivision of the highway department. While some existing traffic engineering divisions are not at present expanded to cover their full field, this is due to the time necessary for their development rather than to the function of the elements not yet covered.

Of the total volume of facts being covered by highway planning surveys, proportionately few are not of very great interest and use to traffic engineering. This is true, of course, only if the traffic division takes a broad view of the field of transportation.

It would be difficult to visualize the combining of the highway planning survey with such older divisions as construction, maintenance, or surveys and plans. This is true largely because they deal with the physical functions rather than the movement functions. This does not mean that such older divisions do not need survey facts—they do—but they need only a small proportion of the total facts because they are not operations divisions.

From this discussion it appears that the logical choice regarding the

location of the highway planning surveys must be either to leave this unit as an advisory group or to combine it with the traffic engineering or traffic planning division.

It is believed that, where it has not already been done, the status of highway planning surveys would be improved by permanently locating this unit and giving it the same strength as construction or maintenance divisions, rather than by leaving it in a nebulous position. As a general rule, operating units of government have greater strength and permanence, resulting from larger budgets and personnel, than do advisory units, whose real worth unfortunately is often not appreciated.

Consolidation of the highway planning survey and traffic engineering would appear to have another advantage. In the eyes of engineers the operating organization always seems to be more practical than the non-operating or advisory agency, on the ground that members of the latter may do much thinking but do not have to face the test by fire of practical application. Regardless of the equity of the case, the situation is based on a practical fact and must be considered: if the advisory agency is looked upon as "theoretical" then its facts can never get their maximum use.

The personnel of both the highway planning survey and the traffic engineering division stand to gain by consolidation. The highway planning survey men get a more stable and more conventional status, a greater use of the facts they collect, a more practical appearance, and a solidarity that goes with a larger over-all division. The traffic engineering men gain increased opportunities for obtaining factual information, stimulation along planning lines, and the values of a larger division. By pooling the funds and the personnel the new composite division would suffer less by comparison with such larger divisions as construction or maintenance. Furthermore, this pooling would tend to eliminate duplications and inefficiencies which even the best administration cannot avoid with two separate operating units.

If it were decided that the highway planning survey and traffic engineering should be combined, then careful consideration should be given to the naming of the new division. "Safety division," though it may have public-relations values, would not adequately describe the combination; it leaves out congestion as well as planning. The term "traffic engineering division" can have a sufficiently broad meaning to traffic experts. But though it does automatically include congestion as well as accidents, it does not give sufficient emphasis to planning in the eyes of engineers as well as the public.

It may be best, therefore, to use a new combination of words to describe the consolidated function, such as that selected by the American Association of Highway Officials for its "Committee on Planning and Traffic Engineering." Thus a "planning and traffic engineering division" or a "traffic

engineering and planning division" might be a sound solution. Consideration should also be given to such titles as "transportation division" or "division of highway transport." It is believed, however, that at the present time such terms would not be understood sufficiently clearly by most of the highway engineers or the public. The jump from a "safety division" to a "transport division" is a long one, and it may be best to make the transition gradual. There need be nothing permanent in a title. Titles should be changed as functions change, so that the words in the title accurately describe the activities of the division.

The suggested consolidation should be a mutually advantageous one—it should not be a case of either function swallowing the other. In larger states the new division of planning and traffic engineering should be headed by a director or the equivalent. Each function could have its separate head with the title of assistant director. In this manner the personnel of neither unit would feel that they had lost status by the consolidation.

If the new division of planning and traffic engineering were established, some of the facts gathered by it would still be used by other departments, of course; in any event the combined division represents better administration than two separate units doing the work. The primary job of this new division would be to determine what facilities are needed where, and of what quality and quantity to serve the automotive transportation requirements of the people of the state, to measure the ability of the motorists to pay for these facilities, and to arrange for the carrying of traffic safely and rapidly by engineering methods. This would permit it so to advise the highway officials that a complete long-range program of road building and traffic control could be projected.

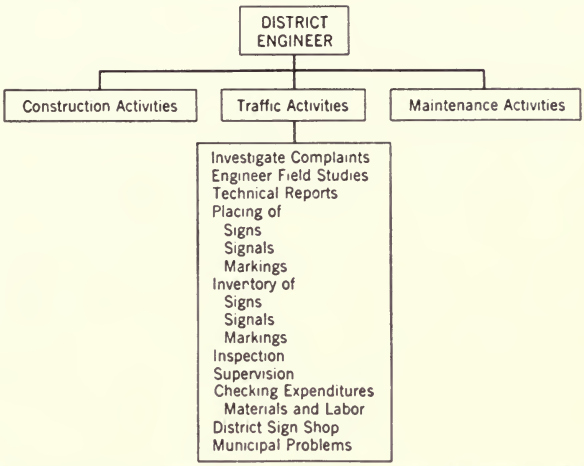
Functional Organization

When the full potentials of traffic engineering are realized, it is doubly important that great care be given to its organization.

In outlining the functional set-up within the state traffic engineering division, the main units may be listed as follows: (1) traffic facts; (2) mechanical control; (3) traffic design; (4) local problems; (5) office operations; (6) permits; (7) departmental vehicle safety; (8) field or district divisions; (9) research. Each of these is of such size as to require a trained man in charge and eventually to have subdivisions and assistants. The following are the functions of each of these basic units:

1. Survey or Fact-Finding Unit. This unit collects and analyzes all facts pertaining to free-wheel transportation. The most common types of surveys it will conduct are as follows: (1) traffic volume; (2) traffic

DISTRICT ORGANIZATION FOR A STATE HIGHWAY DEPARTMENT WITH SPECIAL REFERENCE TO TRAFFIC ENGINEERING



Courtesy of J. Edward Johnston, Traffic Office Engineer, Nebraska State Highway Department.

classification; (3) origin and destination; (4) speed and obstruction; (5) law observance; (6) accident studies; (7) congestion studies; (8) mechanical control studies; (9) economic studies; (10) driver performance studies; (11) special design performance studies; (12) special studies of specific locations; (13) traffic planning studies; (14) traffic zoning and control studies. In general these surveys will be of three *types:* a broad comprehensive survey every two or three years, yearly short count surveys to keep basic data up-to-date, and special spot surveys growing out of particular problems or special locations with special difficulties. These functions will require a fairly small trained staff to supervise all surveys and a small field force to conduct the short counts and special studies. Traffic checkers for larger surveys can be recruited on a temporary basis from within other divisions of the department or from without. The necessity for checkers may be reduced as mechanical counters are further developed.

2. Mechanical Control Unit (Signs, Signals, Markings, Islands). The functions of this unit are to establish the necessity for such controls, determine the proper type, and install and maintain these devices, which are as essential to the traffic facility of the roadway as the foundation itself. This unit must be in charge of a trained man capable of analysis, design, and operations. In large departments it will be essential for him to have four assistants, one in charge of each subdivision. This unit will have to prepare a manual of standards. It will have to have a field force to install and maintain, or one foreman in each district to do the installation on work orders. This unit has particularly high public-relations values to the highway

department because its work is visible to the motoring public, by which the public will generally measure the activities of the whole department.

3. Traffic Design Unit. The function of this unit is to work with such divisions as design, project, and right-of-way, and to check all proposed designs, from the viewpoint not of the structural strength of the roadway but of its ability to carry traffic safely and rapidly. The traffic design engineer should be brought into play at the early stages of the projection of any new facility. If the development of the new facility is allowed to progress to the stage where plans have actually been drawn before he is brought into the situation, he will not have much effect because there will be too much work to unwind. Before actual construction is started on any plan it should be formally approved by the traffic engineer, and a routine clearance form developed for this express purpose. The personnel for this function will require one traffic-trained man and several engineering draftsmen.

4. Local Problems Unit. The function of this unit is to work with local officials of cities and towns on problems affecting state highway routes within municipal jurisdictions. A state system of highways cannot be successfully operated if the local links are ignored. More and more these local links are becoming the bottlenecks in the state transportation system. Hence, in order to get the job done, the state must assume the leadership in working with local authorities. Furthermore, communities of less than 50,000 population (or, in some areas, less than 100,000) cannot afford to maintain a full-time city traffic engineer and must receive their traffic engineering advice from the state highway traffic engineering office, regardless of whether or not a state route is involved.

It appears to be sound policy for the state to contribute such services not only to protect its own system but also to obtain the high public-relations values which this service will produce.

In every large state there will probably be a sufficient number of these local problems of critical interest to the state to require the full-time services of one trained traffic engineer for this purpose alone. It is highly desirable that the highway department receive by law, as it has in Massachusetts, supervisory authority over the installation and operation by cities and towns of all signs, signals, markings, islands, and regulations relative thereto. This may be the only sure way to guarantee that uniformity can be obtained.

5. Office Operations Unit. The functions of this unit are similar to those of any other major unit in the highway department. They include statistics, drafting, presentation, office management, payroll, secretarial, stenographic, mimeographing, printing, filing, etc. In a large organiza-

tion this would require about one office manager, two secretaries, a chief clerk, three typists, and two clerks and draftsmen.

6. Permit Unit. The functions of this unit are to check and approve applications to permit property owners to enter the highway (cut curbing or change shoulder) or for oversize or overweight vehicles to operate on the highway under special permits. Since the effect of these factors upon moving traffic is greater than upon any of the activities of the highway department, this permit function logically belongs in the traffic engineering division. This division should at least have approval powers over such permits.

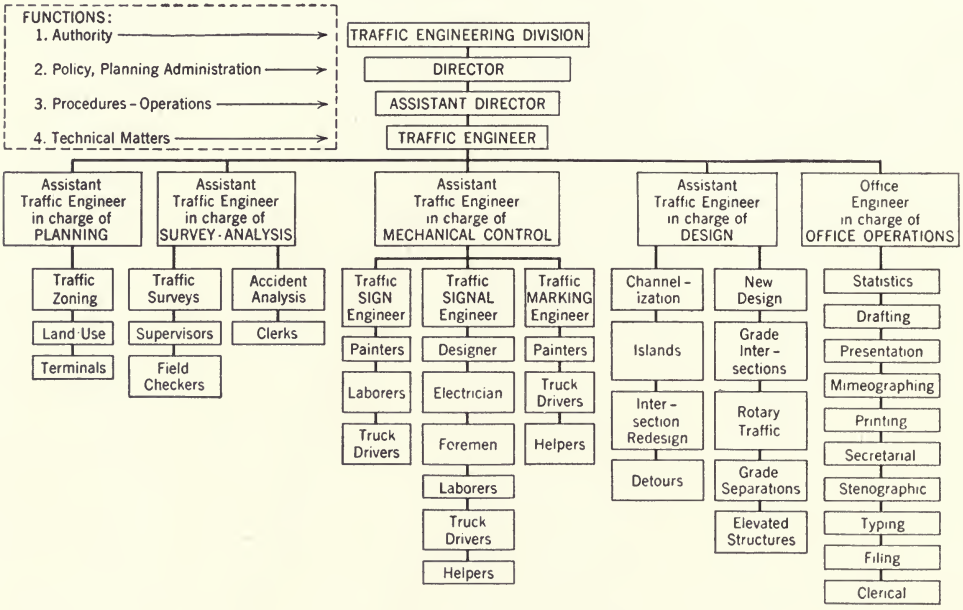
7. Departmental Vehicle Safety. Some highway departments have found it to their advantage to control the operation of the vehicles used by their department rather than to turn over this control to the motor vehicle department. In other states, such a safety department has been broadened to include all safety activities of employees.

8. District Traffic Engineers. In many states it has been found necessary, for geographical reasons, to decentralize some of the activities of the highway department with proper mechanisms of staff and line control. The advantages of this plan are (*a*) considerable savings in transportation costs. (*b*) savings in man-hours of staff time, (*c*) increased knowledge of local conditions by local man in residence, and (*d*) increased speed of service, so that emergencies are better cared for and a more favorable impression is created. Since most departments have districts, the district traffic engineer should follow the existing pattern. This will usually provide one man per district, or about seven district traffic engineers. In some places a regional traffic engineer may be needed to supervise two district traffic engineers where one part of the state is a self-contained unit. In others one traffic engineer may replace two district traffic engineers in districts having light traffic and few highways, cities, and towns.

These district traffic engineers will usually have to have assistance for controlling equipment installation and operation. There are a large number of laborers and foremen in most districts. It would be advisable for at least one foreman and five laborers of this group to be placed under the control of the district traffic engineer. If these men are employed more than half the time on traffic they should report to the district traffic engineer and be temporarily assigned or loaned to non-traffic work during slack periods in traffic work or during a serious emergency. Unless this control procedure is followed, the red tape and split responsibility will greatly reduce the efficiency of traffic engineering operations and cause much internal friction.

9. Research Unit. Present operations must be carried on, but this by itself will only perpetuate the present system. It is thus essential that a separate unit be set up to seek improved ways of performing the necessary functions.

SAMPLE ORGANIZATION OF A FULLY DEVELOPED TRAFFIC ENGINEERING DIVISION IN A CITY



The organization charts show the detailed functional divisions and lines of authority for a large state including the location of the division within the department, the details of the traffic engineering division, and the following classified personnel:

A. Director—administrative and public-relations work.
B. Assistant director—administration.
C. Traffic engineer—chief technician.
D. Assistant traffic engineer—in charge of traffic surveys and accident analysis.
E. Assistant traffic engineer—in charge of mechanical control, signs, signals, markings.
F. Assistant traffic engineer—in charge of design.
G. Assistant traffic engineer—in charge of local problems.
H. Assistant—in charge of office operations.
I. Assistant—in charge of permits.
J. Draftsmen.
K. Statisticians.
L. Secretaries and stenographers.
M. District traffic engineers (1 for each district).
N. Field counters (permanent and seasonal).

This theoretically desirable functional organization naturally will have to be adjusted to permit its gradual development with the personnel that is available from time to time. It may be advisable at first to combine two of the units, which may later be divided as another man becomes available or the work increases. By the same token it may be necessary to create new subunits as the volume of work increases. An example of this may be found in the mechanical control division, where one man may have to be put in charge of signs, another in charge of signals, and a third in charge of marking.

Even though it may be necessary to delay the establishment of the division or of some subdivision of it until the right man is found, this delay should not defer the advantages of organization any longer than can be helped. Under some circumstances it might be better to install a temporary head while the proper man is being trained.

It is sound policy to adhere as closely to the functional form as possible rather than to rely upon the personnel's trying makeshift adjustments to make the machinery work.

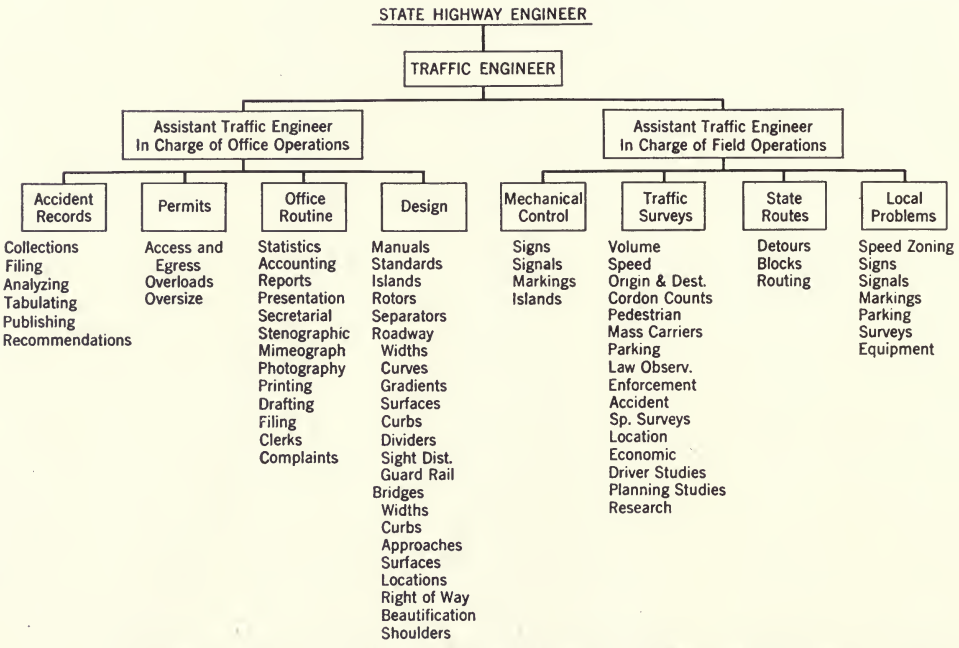
In summary, it has been shown that highway departments and city engineering departments have passed through many stages. As conditions have altered, they have had to change their internal organization to give emphasis to those parts of the problem needing the most attention at the time. If a department is to be efficient, it must constantly adjust. Thus a change to establish a new unit in no way means that the past method was wrong; it merely means that conditions have changed so much that a new unit will bring increased efficiency.

In a highway department the construction division plays the major role in providing the facility. The maintenance division is responsible for keeping the facility in serviceable condition. The traffic engineering division has the responsibility of seeing that the facilities are created where and when they are most needed to meet traffic demands; it must make sure that the design of those facilities meets the necessary functions of the traffic load; it controls the use of the facility by mechanical devices and channelizing islands, and protects these operating functions through traffic planning. Thus it is natural that during a basic construction era the formalized unit of the department which predominated was construction. With increased mileage and more maintenance, the maintenance division grew; and likewise, as increased volume and speed developed, creating a more critical operations problem, a new unit—a traffic engineering division—emerged to handle it.

Since the form of organization must follow changes in the problem, it is hard to predict the necessary subdivisions of the traffic division. The best that can be done is to analyze the problem from a functional point of view, establish those functions that are already important enough to warrant a full-time trained man, and consolidate the remaining functions until they grow to an equally important point. As they grow, they should be made separate subunits until the number of men reporting directly to the administrator becomes unwieldy. The functions may then be reconsolidated until the proper administrative and functional balance is reached.

SAMPLE ORGANIZATION OF A TRAFFIC ENGINEERING DIVISION

Evolved from an original 3 man staff



Courtesy of J. Edward Johnston, Traffic Office Engineer, Nebraska State Highway Department.

CHAPTER VII

ADMINISTRATION OF TRAFFIC DIVISION

In many traffic divisions the organizational set-up—the factory-—has been completed and is ready to operate. As has been indicated, sound organization is highly important and must be achieved before the administrative phase is worked out. The development of effective management, it is being discovered, is as difficult as some of the other stages through which traffic engineering has progressed. No matter how well a department is organized, or how sound and well trained its personnel, the final product—the improvement of transportation—will be no better than the department's operation. The technique of managing a traffic engineering division is particularly difficult in view of the large number of older and thoroughly entrenched departments and subdivisions which must be dealt with, and of the fact that traffic engineering operations affect all citizens in their daily lives.

The management of a traffic engineering division must be developed to a point where its work will result in fewer accidents and less congestion. Unless this goal is attained, the existence of a traffic engineering division cannot be justified, nor will it be possible to obtain the proportion of the highway budget merited by motor-vehicle transportation. It may be added that, unless the salary level of governmental traffic engineers is lifted, the field of traffic engineering cannot hold the splendid calibre of men it now has, for the men will tend to move to more lucrative positions.

ADMINISTRATION OF A TRAFFIC ENGINEERING DIVISION IS IMPORTANT. It Is Vital that Authorities, Responsibilities, Channels of Staff and Line Control, Procedures, and Forms Be Worked out. Many Highway Departments Have Manuals on Construction and Manuals on Maintenance. A Similar Manual on Traffic Engineering Must Be Worked out. The Following Are Some of the Elements Involved.

1. **Functions of Director.** In larger departments the head of a division is frequently called the director. His functions are more administrative than technical, and he relies upon his chief technician, who carries the title of traffic engineer and who reports directly to him. The director or traffic engineer, being on a par with the construction engineer and the maintenance engineer, reports directly to the chief engineer and attends all staff meetings of the highway department.

2. **Functions of Assistant Director.** The assistant traffic engineers and all other staff members of the traffic engineering division report to the traffic engineer through their respective supervisors. If the district system of the highway department of a particular state is on a decentralized basis, then the district engineer will be in full charge of all operations within this district and the district traffic engineer will report to him on a line control basis, but will receive his staff control from the traffic engineer in the central office. If the district system of a highway department is on a functional decentralization basis, then the district traffic engineer reports directly to the traffic engineer in the central office and thus staff and line control is identical.

3. **Coordination of Functions.** All traffic engineering functions must be coordinated with all other functions of the highway department or city engineering department. The following are examples:

(*a*) Fit all new devices into any new design.

(*b*) Check the effect of traffic devices on snow removal or maintenance.

(*c*) Work out safe detours with construction department.

(*d*) Check proposed signal with plans to see if major intersection redesign is proposed.

(*e*) Traffic design engineer must check with design division on all future design.

4. **Internal Administration.** This involves relations between the traffic engineering division and other departments and subdivisions of government. No state traffic engineering organization can operate successfully—or, for

that matter, exist—if it does not maintain satisfactory relations with the following units of government:

1. Other subdivisions of the highway department:

(*a*) Commission, administrator, and chief engineer.
(*b*) Surveys and plans division.
(*c*) Project division.
(*d*) Location division.
(*e*) Design division.
(*f*) Right-of-way division.
(*g*) Bridge division.
(*h*) Roadside development division.
(*i*) Construction division.
(*j*) Finance and accounting division.
(*k*) Purchasing division.
(*l*) Maintenance division.
(*m*) Public-relations division.
(*n*) District engineers.
(*o*) Highway planning survey.

2. Other state government units related to traffic:

(*a*) State police or highway patrol.
(*b*) Motor vehicle department.
(*c*) Board of education.
(*d*) Utilities commissions.
(*e*) Conservation department.
(*f*) Planning board.
(*g*) Industrial division.
(*h*) Railroad commissions.

3. City and town officials.
4. County highway officials.
5. U. S. Public Roads Administration.

The administrative problem begins with the highway department. Issuance by the commission or the chief engineer of an administrative order setting up the traffic engineering division does not solve the problem. The traffic engineering division must take certain powers and a certain proportion of the budget and personnel away from other divisions which have had them for a long time. Hence the change is likely to be resented, for division heads, being human, seldom if ever want to lose authority, funds, or manpower.

The chief executive and the commission may favor the establishment of a traffic engineering division in a general way, without, however, always realizing all the implications of such a move. Hence it is the duty of the traffic engineer to spend the necessary time with them to develop an understanding of all the factors involved and to insure their complete support. Such support should comprise a strong administrative order, a personal plea by the chief engineer or commission chairman for cooperation and assistance of the older departments for the new division, and a general meeting at which the new set-up may be thoroughly explained.

The traffic engineer must be prepared to cooperate with other units to which his work is related. Thus he should play an active part in determining where new highways are needed. The project division usually starts

the action on all new roadways; the traffic design engineer of the traffic engineering division should participate in this at the time the center line of a projected roadway is laid down, or better still when general locations are being considered. Otherwise the best design, from the traffic engineering standpoint, may not be attainable, owing to geographic limitations of the location selected. Once construction work is started, it is usually difficult to alter the plan.

Similarly, the traffic design engineer of the traffic engineering division should act in close collaboration with the design division of the highway department for the purpose of working the best geometric design into the plans of the physical or structural design. Because frequently conflicts will arise between the requirements of traffic movement and of physical construction—for the reason that one plan may cost more than another—it is essential that the position of traffic designer in the traffic engineering division be established. This will insure full consideration of the traffic safety and congestion point of view. The construction engineer's or the traffic engineer's viewpoint alone would be incomplete. This places the chief engineer in the position of arbitrator when differences of opinion arise. The same reasoning applies with regard to the work of the bridge division.

Cooperation with the construction division is necessary to prevent changes that may prove detrimental to traffic movement, for example, as to type of surface, pavement color, lighting, and reflectors in curbing.

Cooperation with the maintenance division is particularly necessary. The work of this division may be inconvenienced or affected by some traffic engineering proposal, and misunderstandings may develop unless every such proposal is made clear to the head of the maintenance division.

The traffic engineer should maintain close contact with the public-relations division to make sure that traffic engineering activities receive a fair proportion of public recognition. This should not be difficult to achieve, for traffic engineering activities are more readily visible and have more public interest than most other activities of the highway department. Most motorists quickly react to signs, signals, markings, islands, and good traffic design, but few can appreciate good highway planning, construction, or soil mechanics practices.

In large states, where highway departments are decentralized, the district engineer has strong authority over activities in his jurisdiction. In such cases the traffic engineer must work closely with the district engineers if he wants his plans to be carried out.

The city traffic engineering division must follow the same procedure with the departments and subdivisions of city government as the counterparts of the state units previously listed. Cooperation and coordination

with the police department, the planning board, and the traffic engineering division of the state highway department are especially important. In cities there will be some departments without counterparts in the state with which cooperation is essential. Among these are the following:

1. Fire department.
2. Park department.
3. Electrical department.

5. Administrative Procedures. In new organizations there is a tendency to deal with problems one at a time as they arise. This causes the work to pile up, leaving little time for finding better, quicker, or more economical methods of getting results. Experience dictates the wisdom of reducing most general operations to routine procedures. This channelizes the effort and develops patterns that may be easily followed without stopping to work out a new method each time. The procedures thus developed, which should be brought together in a manual, include such typical details as the following:

(1) Requests for or complaints about signs, signals, etc.
(2) Typical surveys and all field investigations.
(3) Form letters and interdepartmental memoranda.
(4) Filing of letters, materials, and reports.
(5) Follow-up on most hazardous or delay locations.

Other important procedures relate to the routine of work, specialization, and intradivision and interagency coordination.

6. Codes and Manuals. Once those "best" ways of doing things are agreed upon and put in the form of code or manual, they become the standard. Thereafter the chief traffic engineer or any of his major assistants will not have to review each case, but can work more efficiently and save time by dealing only with exceptions. These will always come up, and standards must be altered as methods are improved. Nevertheless codes or manuals can handle the majority of cases, assist in producing workmanlike jobs, and save delay, confusion, and money. Standard manuals or codes should be prepared for such typical items as the following:

(1) Signs.
(2) Markings.
(3) Signals.
(4) Channelization.
(5) Intersection redesign.
(6) Intersection design.
(7) Traffic design for tangents.
(8) Control of access design.

After the standards have been fairly perfected, some of them might be combined into one manual.

7. Approvals and Permits. Forms for approvals and permits should be prepared and their handling channeled so that the authorization proceeds without delay. If investigations are required, a report form should be prepared to cover each type of investigation. If a project or method must be checked against a manual, there should be a statement as to the success of the checking. The routing of approvals and permits is complicated and must be worked out carefully to avoid overlap, duplication, and delay.

8. Fiscal Control. The traffic engineer should bear in mind that budgets must be projected in advance. They must be supported by adequate reports. Expenditures must be allocated on a preference basis and held to a time schedule. Major improvements and replacements must be projected over a period of years. Expenditures must be authorized and the proper forms prepared. An audit system must be established.

The traffic engineer in charge should also remember that, unless all expenditures are justified by benefits received, it will be difficult to obtain increased appropriations. Ultimately all traffic engineering activities which lessen accidents and congestion will have to be reduced to dollar values. Only in this way can the highest efficiency be developed, so that funds are spent for such improvements at such places as to produce the greatest return per dollar invested. Current differences of opinion as to what amounts are to be assigned to the delay factor or to the relative severity of each accident should not restrain the traffic engineer from the aim of securing an economic yardstick. Regardless of the degree of accuracy, dollar figures, as long as they are used consistently, have good comparative value: the dollar is the only common denominator between income and expenditure, and besides, it is the one denominator familiar to the public.

9. Public Relations, Politics, Public Education. It is important that the traffic engineer have a clear concept of the part that public relations, politics, and public education can play in support of a sound traffic engineering program. He should realize that he is a public servant employed not only by motor-vehicle users but also by the community at large to provide faster, safer, and more economical automotive transportation. If the motorists and the rest of the public feel that he is doing his job well, they will support his program; otherwise they will withhold their cooperation. The motorist is not a traffic engineer, but he is likely to think he knows a good deal about traffic, and will judge the program exclusively by what he sees and hears. Consequently, merely doing a good traffic engineering job is not enough to win public support; results must be constantly demonstrated and explained. Moreover, it has been shown that traffic engineering activities that can readily be seen and appreciated by the motorist have

more sales value for the entire program than activities with lower visibility factor which are not seen so easily or understood so widely. Hence the traffic engineer who wishes full public support would be wise to use all the signs, signals, islands, and markings that can be justified by traffic conditions, for these are the tangible evidence of his division's work. Naturally unjustified equipment would only make conditions worse.

Here the practical traffic engineer may remark, "That's all very well in theory, but the fact is that the budget and authority for traffic engineering come not from the public but from government heads, and hence pleasing the public may not bring the desired results."

Admittedly the political heads control the administration and the funds in many jurisdictions. Under these circumstances the traffic engineer cannot make progress with his program by antagonizing or refusing to cooperate with political appointees. Instead, he must be courteous to them and strive to find a common ground where both the necessities of politics and the needs of traffic will be served. This may not appear so difficult when it is considered that those in political positions have constituents. These constituents are the same motorists and pedestrians whom the traffic engineer is trying to help. If they are satisfied, this will be felt by the political officeholders. In the long run, the latter must give the people what the people want—though there often is a considerable lag between public demand and political or legislative action to satisfy such demand.

However inconvenient this may be to the traffic engineer, it should not alter the sound process of getting support by satisfying the public's needs and wishes. Eventually, if the public is not satisfied, merely pleasing the political heads will not save the traffic engineer. Political heads try to convince the public of the soundness of their ideas. The traffic engineer should consider the motorist and pedestrian as his constituents, and likewise try to influence them in favor of his ideas. If his influence is sufficiently strong—and political pressure does not block him—he will win.

Some students of traffic control argue for getting traffic out of politics. They feel that progress is impossible unless the traffic engineer is freed from political influence in a negative direction. The author holds that the thing to do is to get traffic into politics—but only in such a way as to secure the support of political heads for a good program. This does not mean that the traffic engineer should carry on political activity such as making partisan speeches, using his office to support a candidate or party, or granting political favors. Rather, it means that he should bring sound traffic engineering projects to the attention of the controlling political heads and point out the value of his projects to the public and the constituents in the areas affected.

It is not possible to get traffic out of politics without reforming government. Hence the only basis for successful operation is for the traffic engineer to cooperate with the political heads and strive to convince them that the sound program he would like to put into effect will be popular with the voting public, and that the political head will receive adequate credit for the improvements. This type of approach has proved effective. It presupposes that the traffic engineer should not look upon political workers as enemies and that he give them credit for experience and expertness in their field. It means that the traffic engineer under difficult circumstances must be willing to grant a few innocuous requests for paint lines or signs, but only where they will not be harmful, in return for support for his program.

The fundamental point is that technical information and expert personnel alone will not accomplish the desired outcome. It is essential to gain the public's long-run support. The heads of government and the political workers are important factors which cannot be ignored. The traffic engineer must work closely with them to obtain their support, while refraining from all outward political activity. Otherwise the traffic engineering department will be hampered in its operations, or possibly suffer elimination by political pressure.

10. Reports. If the traffic engineer is to get credit for his accomplishments, he must maintain detailed records, make before-and-after studies to prove the benefits of his actions, and issue monthly, annual, and special reports. These reports should contain such items as:

(1) Reduction in accidents, before-and-after cases.
(2) Reduction in delay, before-and-after cases.
(3) Number of signs installed, replaced, repaired.
(4) Miles of paint lines painted.
(5) Number of signals installed, replaced, repaired, retimed.
(6) Number of islands installed.
(7) Number of intersections channelized.
(8) Number of intersections redesigned.
(9) Number of new intersections and roadways designed.
(10) Number and types of surveys made.
(11) Number of complaints investigated and requests answered.
(12) Number of public contacts, speeches, articles, exhibits, etc.
(13) Increase or decrease in traffic flow.
(14) Budgetary statement.
(15) Budget expenditure and justification.
(16) Office studies completed.
(17) Legislation or regulations proposed.
(18) Personnel activities; honors; promotions; advances; training; etc.
(19) Municipal cooperative activities.

The form of the report is most important, and should suit the type of reader for whom it is intended. If the report is to be read by people not

in the traffic field or by citizens or legislators not interested in technical details, it should be generously illustrated. If it is to be read by executives, it should have the summary and recommendations in front, followed by a concise statement of accomplishments, and—for those who wish to go into particulars—the supporting data in the appendix. The report is an excellent way to avoid the time-consuming writing of letters to answer requests for information. It makes an effective sales document, and it is well worth the money to prepare a fairly ample supply of copies.

11. Staff Meetings. It is axiomatic that no organization can be administered efficiently unless the key men are called together at frequent intervals to discuss problems, report progress, adjust the program, and make plans. Such meetings give the personnel a feeling of being important parts of the division. They also give opportunity to vent serious differences of opinion or dissatisfaction. Occasionally the district men and even the detail workers should be called to attend such conferences.

12. Staff Credit. It is important that the head of the traffic engineering division give adequate personal and professional credit to his assistants. He should build up these men as future administrators, and encourage them to take part in professional activities, such as serving on committees and preparing articles.

13. Training. Equally important is the in-service training of employees. If they are not encouraged and given a chance to enlarge their knowledge, they may never grow or reach their potential ability. A program to accomplish such training should include a traffic library, monthly bulletins on new traffic developments, a week's traffic course run by the department with the assistance of outside guest lecturers, and opportunity for some of the men to attend short courses or graduate courses in traffic engineering.

14. Work Schedules. A helpful administrative tool is the work chart or schedule. The simple pressure of routine work makes it difficult to plan. Unless all routine work and assignments are scheduled and charted, the work will never be kept up to date and no time will be salvaged for planning, research, or improvement of methods. Definite deadlines should always be set, even if often they may have to be adjusted.

15. Basic Plans. An allied process is the development of a basic plan for the year. This involves the determination of what can be completed in that time with the manpower and funds available, and the selection of activities which should be given priority. Sound planning represents a most difficult administrative process; it may be said that in practice its technique lags behind that of most of the other processes. Among the elements which should be considered in making up a year's plan are:

(1) Locations having the most accidents and/or congestion.
(2) Amount of funds and manpower available.
(3) Season of the year and the weather.
(4) Those activities having a high public-relations value.
(5) Projection or completion of large-scale projects.
(6) Complaints and pressure, other things being equal.
(7) Times of political pressure, other things being equal.
(8) New construction to guarantee adequate performance.
(9) Locations where a relatively small expenditure will bring the facility to a 100 per cent condition.
(10) Continuity over important trunk lines.
(11) Availability of materials.
(12) Proximity to communities where a serious departmental relationship exists, other things being equal.
(13) Units to fit into a long-range plan for 3-5 years.
(14) Concentration to produce a strong demonstration.

Item 14 warrants special explanation. A major difficulty today in merchandising good traffic engineering elements, controls, or designs is the dearth of excellent examples with excellent results which can be used as samples or illustrations. If examples of actual use cannot be presented, the traffic engineer's idea falls in the theoretical class and hence will be difficult to put across. Thus strenuous efforts should be made to have at least one 100 per cent perfect case of each traffic engineering technique—signs, signals, markings, islands, channelization, intersection redesign, new intersection, stretch of highway illumination—and, if at all possible, one "ideal" route having a high rate of safe speed. If, to cite an instance, most signals are only 40 per cent effective or useful, it will be difficult to get money to improve them or to install additional ones unless one case can be held up, shown to people, and pictured to show exactly what is desired.

16. Research. Traffic engineering cannot progress unless both theoretical and practical research are conducted to find out better ways of moving traffic more expeditiously, more economically, and more safely. Research takes time, personnel, and money. In some way, about 10 per cent of each of these items must be salvaged from routine work and devoted to research. Research should appear in the budget and on the organization chart as a regular activity of the division. Little solid progress can be made in research by trying to steal a little time and money for it from other operations. It must be brought into the open and pushed.

17. Personnel Control. Each man must be given clean-cut authority and responsibility, or he will have little pride in his work or be reluctant to act, fearing to step on someone else's toes. For every important position the division should be training a second man who will eventually move up into that position. Nothing is more discouraging than a department with

excellent men at the top and at the bottom, but with men of poor calibre in the middle. Promising young men must be employed at the bottom, later to move up through training and experience. Frequent though small increases are far better for maintaining the division's morale than large but infrequent ones. To avoid confusion and irritation, the men must be taught how line-and-staff control operate.

18. Professional Contacts. A significant administrative procedure is frequent contact and exposure of the executives and junior executives to keep posted on new developments, broaden their outlook, and give them confidence through checking their conclusions. Travel, committee work, and contact work are strongly recommended for these purposes.

Naturally any member of the personnel interested in the field of traffic engineering will find it to his advantage to take an active part in the Institute of Traffic Engineers—by becoming a member if he is qualified, serving on committees, writing technical articles, and attending meetings.

The Institute was formed October 2, 1930, with 19 members. By 1941 the membership reached 216, representing all sections of the country. Its purpose is to advance traffic engineering, develop standards, foster professional education, stimulate research, improve its members professionally, and establish a clearing house and center for mutual interests. It publishes a monthly professional magazine, several technical reports and monographs each year, and the proceedings of its annual meetings.

Through the leadership of this institute the field of traffic engineering has obtained general professional recognition. Its influence has done much to mold professional thinking of officials and organizations along the lines of more efficient transportation.

Space forbids discussion of other administrative and quasi-administrative functions. In an organization of fairly large size, administration is practically a full-time job that will leave little time for technical supervision or detailed technical work. Without adequate administration the best work will not be obtained from the men, additional funds and manpower will not be secured, and the field of traffic engineering will not advance to its maximum potential importance. The traffic engineer may be saddened by the fact that once he becomes an administrator he probably will not be able to devote more than a fraction of his time to pure engineering, if he is to get the program under way and to advance himself and the profession. He may find compensation in realizing that the objectives are more important than personal feelings, and that traffic engineering administration is worth improving.

19. District Procedure. In a department in which a district engineer is in complete charge of all matters related to his district, the following is a

suggested procedure when a local problem develops or an important complaint is received:

(*a*) Traffic problem occurs in a district and is discovered by the department through a complaint.

(*b*) District traffic engineer studies problem, obtains facts, makes analysis, and offers recommendations.

(*c*) District traffic engineer checks with district engineer to learn of any other conflicting plans.

(*d*) District traffic engineer forwards formal report to chief traffic engineer.

(*e*) Chief traffic engineer reviews report and checks with head of other departments.

(*f*) Chief traffic engineer forwards final comprehensive report to chief engineer.

(*g*) Chief engineer approves plan and issues orders to district engineer and heads of other departments involved.

The district system would be used in large states and perhaps in large cities. In New York City the five boroughs operate as five districts in many ways. The full development of a traffic division would eventually place a district traffic engineer in each geographic unit.

20. Authority. It is important that the traffic engineering division, or the main department of which it is a part, be given strong legal authority over traffic control. It is equally important that this authority be given in a way to make it workable.

Authority should include power to issue such regulations as one-way streets, through streets, and no parking, on a sixty- or ninety-day trial basis. These should be lawful at the time they are made. At the end of that period there should be provision for a public hearing. If serious opposition did not develop, the regulation would then become permanent until changed by the authority. Appeal might then be made to the traffic commission, which should have the authority to rule on it. Recourse would naturally still be available in the courts. This process would be found much more satisfactory than requiring public hearings first, at which much red tape might develop and undue delay occur. It would be preferable, also, to attempting to handle regulations by legislature or council, with non-technical men trying to pass upon technical matters. Such process, besides, is far too cumbersome and slow for such a subject as traffic, in which conditions at a particular point may change over night and an immediate change in the regulation be required.

Principle 22

A SEPARATE TRAFFIC ENGINEERING BUDGET IS ESSENTIAL: A Separate Budget Is Essential if the Division Is to Have Any Feeling of Stability, if Accurate Costs Are To Be Determined, and if Traffic Accidents and Congestion Are To Receive the Relative Proportion of Expenditure Which They Deserve.

The total amount of the traffic budget will differ with each state. When a traffic engineering division is being established for the first time, it will be exceedingly difficult to decide on the proper budget. In many states the budget is not classified in sufficient detail to indicate what is being spent at present on traffic. The following procedures are recommended:

1. Make a detailed analysis of the present budget and list all expenditures in all departments on traffic engineering matters. These will include surveys, signs, signals, markings, islands, special investigations, road maps, traffic design plans, etc.
2. Next, make a study of the number of men and man-hours which have been applied to these, and their salary cost.
3. Estimate the office operations, transportation maintenance, and normal operations costs which such activities require.
4. Make a study of the trend of capital expenses for traffic equipment.

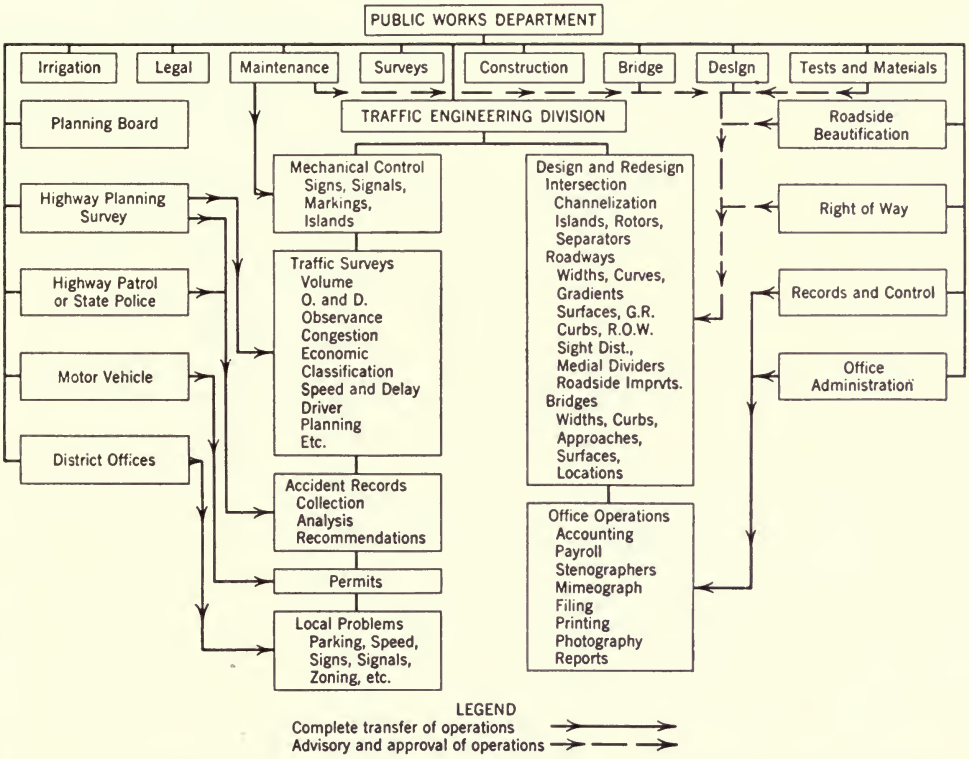
From a study of these items as they appear over a period of years, present costs of traffic engineering activities may be evaluated. The percentage of the total highway budget that this cost represents should next be obtained for comparison with other states. This comparison will provide a rough basis for making a start. Even if the newly formed traffic division does not receive any more than has been spent in the past, probably more will be accomplished by a more efficient expenditure of the funds and a more accurate traffic-cost accounting system. The author firmly believes, however, that in most states additional funds for traffic engineering can be economically justified and that such expenditures will render the highway system much more useful to the public. Past construction and maintenance did much to haul the car out of the mud—an essential first step in providing a transportation system. However, in the last analysis the most important element of a transportation system is the speed and economy with which persons and commodities can be transported. A splendid economical foundation and a surface that can carry traffic safely at only 15 miles per hour in cities and 40 miles per hour on highways is not an economical structure.

The chief function of traffic engineering is to increase the safe, economical speed of transportation.

The costs of accidents and congestion must be measured to determine the justification for all expenditures. In the absence of definitive information on economic losses, it is recommended that a start be made to secure this information. If the worst intersections, curves, hills, and stretches of roadway are selected, it would be a fairly simple matter to measure the present loss in dollars of accidents and congestion.

Insurance companies have established figures for accident costs. Many engineers feel that one cent per minute per vehicle is a conservative value for traffic delays. If the accident and delay costs are known at one intersection, this may then at least serve as a yardstick in comparing it with other intersections where similar information is available. It may also assist in determining which needs remedial treatment more urgently and how much the department would be justified in spending. This method would appear to be a substantial improvement over proceeding, as we have in the past, without any yardstick. This process should not be delayed over a quarrel about what each accident or each lost minute costs. The principle of the development of a measurement, a new tool, a new yardstick, is the important thing. Until a comprehensive study has been made each department may set its own figures—at least they will represent a constant and will have excellent comparison values. On the basis of logic and horse sense, the lowest figure that might be set will undoubtedly show surprising losses and disclose gross inefficiencies in the system. The conversion of these losses into dollars has a definite psychological value, as it is a unit which the business man and the average driver understand.

SHOWING CROSS-SECTIONAL CHARACTERISTIC OF STATE TRAFFIC ENGINEERING DIVISION



Courtesy of J. Edward Johnston, Traffic Office Engineer, Nebraska State Highway Department.

Principle 23

THE TIMING OF A NEW ORGANIZATION SHOULD BE GRADUAL. Because the Establishment of a New Traffic Engineering Division Affects So Many Other Divisions, It Must Be Done Only after Careful Study and by Carefully Timed Stages. The Present Situation Must Be Reduced to Report Form in Detail. The Present Personnel Must Be Evaluated. The Future Personnel Must Be Trained. It May Take Considerable Time before the Complete Set-up Can Be in Operation.

In establishing a new traffic division care must be taken not to make changes too rapidly, because considerable harm may be done that will take a long time to repair. The more common of the difficulties to watch out for are as follows:

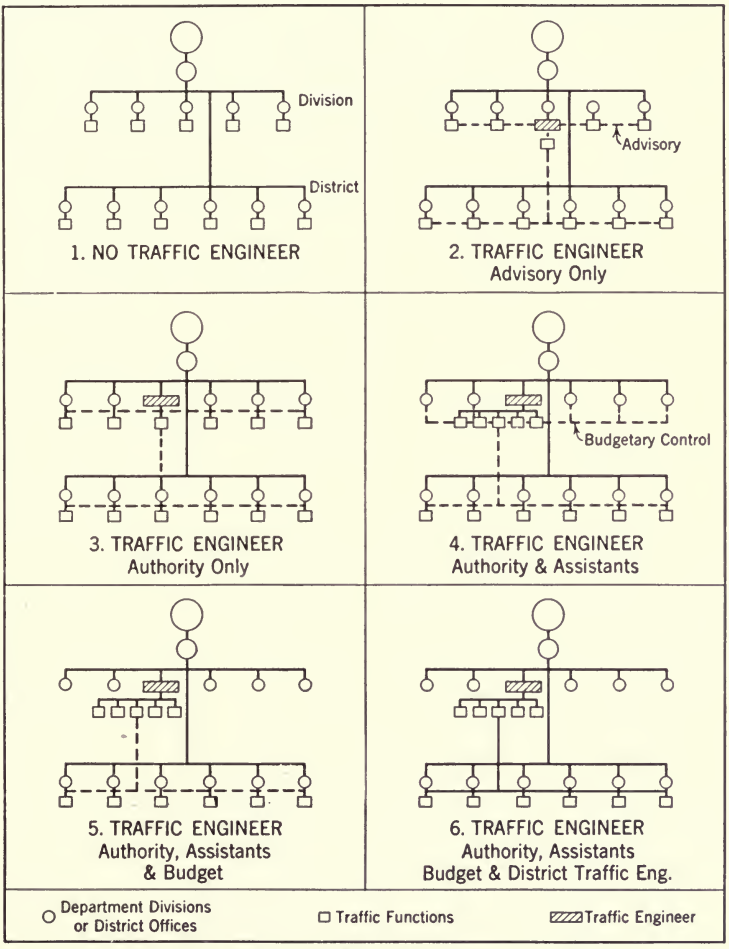
1. **Cooperation of Other Divisions.** Unless all the other units of the department understand the functions of the traffic engineering division and the advantages of a separate unit, and are in sympathy with it, the new organization will not work very satisfactorily. It may even be unconsciously sabotaged by other units still operating under the old habits. For this reason it is strongly advisable to pick out a representative cross section of the men in all departments and send them to a traffic engineering school. This will give them an appreciation, if not a working knowledge, of traffic engineering.

2. **Training Class for Procedures.** Unless the procedures of the traffic engineering division have been carefully worked out, the processes will break down, not by intent, but because of lack of understanding. It is advisable to run a special class to acquaint all the men in all the units of the department with these new procedures before they are put into practice.

3. **Personnel Must Be Carefully Selected.** It takes time to find the men who are most interested and have a special aptitude for traffic engineering. If the wrong men are installed, it is exceedingly awkward to shift them later, particularly if a merit or civil-service system exists. Incidentally, it takes time to acquaint a civil-service system with the requirements of a traffic engineer. The system is faced with the difficult task of creating a new classification and preparing an adequate examination for it. Again, a word of caution is advisable. If the qualifications and examinations are not adequate yet a certified list is developed, this will be exceedingly hard to unwind in order to get a fresh start.

4. **The Personnel Must Be Trained.** As previously indicated, this will take approximately one year. Training is especially important, as it will provide professional dignity and standing which any new field needs in the

PROGRESSIVE EVOLUTION OF A TRAFFIC ENGINEER IN A STATE HIGHWAY DEPARTMENT



Courtesy of J. Edward Johnston, Traffic Office Engineer, Nebraska State Highway Department.

eyes of the older divisions. Only those departmental employees with sufficient background should be sent to training schools.

The steps outlined clearly demonstrate that a new division cannot be undertaken immediately, and that getting an early start is highly important. The demand for traffic engineering divisions exists in every state right now. A well-rounded, experienced highway engineer should immediately be assigned to make the initial survey and be given the responsibility of carrying the plan into execution.

In a large state the survey will take considerable time. It should be started sufficiently early to permit completion of the work by the time general training and orientation have been accomplished.

Principle 24

THE COMPLICATIONS OF THE TRAFFIC PROBLEM REQUIRE RESEARCH AND FACTS. Traffic Surveys Must Be Made and Kept Up-To-Date. Frequently It is Much More Difficult to Find out What the Problem Is Than to Solve It after It Has Been Defined. Traffic Problems Are Far Too Complex to Be Solved by Guesswork.

Since the traffic problem deals with civilization and organized society and goes to the roots of human nature, it is far too complicated to be handled by opinion alone. The temporary expedients of the past show all too clearly the absence of facts, and point toward the fundamental necessity of research. In spite of significant developments along this line during the last few years, hundreds of basic facts are still not known. The automotive industry has spent hundreds of millions of dollars in research to develop its products, the rolling stock, and it is not surprising that this element is ahead of the ability of the roadbed to absorb the potentials of the personnel, or drivers, and the vehicles.

Traffic surveys must be conducted continuously in order that the basic information may always be available. No changes should ever be made unless facts which accurately demonstrate the necessity for the change, and show what kind of a change will be most likely to succeed, have been obtained. Every change should be followed by a check-back to prove the value or the inefficacy of the change. This factual policy consists, in reality, of continuous fact-finding. The facts are altered as changes are made, and it is thus possible to make the kind of changes which will move the facts in the desirable direction. Only facts can show the direction in which the program is going and forecast future requirements.

Careful analysis of facts will also uncover unexpected relationships, which in turn will reveal new techniques.

Traffic research should be recognized as a specific function of the traffic engineering division, and a definite sum should be set aside in the budget for it. It may be possible to set up a separate subdivision in the traffic division to handle research exclusively. Research has had remarkable results in regard to concrete beam tests, soil, paint, oil, and surfacing materials. A start has already been made on the traffic side on such subjects as curbings, guard rails, medial dividers, and supersized signs, including legibility of letters.

It is especially recommended that traffic engineering departments conduct research into the detailed movement of vehicles and build sample new designs on abandoned stretches of right-of-way where they may be tried

out with safety. It may be considered poor practice to spring new designs on the unsuspecting public on the regular highway system. Far too frequently this results in accidents due to minor flaws in the new design, and the highway department is forced hastily to abandon the novel idea. This means that both the design and the department receive a black eye in the minds of the public, and what might eventually have been a definite improve-

Bryant Burkhard.

Formal study with full-size equipment is effective.

ment is set back perhaps for years. If the same design had been built in the department's proving ground, tests could have been made with full engineering instrumentation and the minor errors discovered and corrected before it was presented to the public. Such proving-ground tests would thus foster new design and be very popular with the public.

Principle 25

EFFICIENT AUTOMOTIVE TRANSPORTATION REQUIRES TRAINED SPECIALISTS. The Transportation Problem Can Never Be Solved by Amateurs. Special Professionals Must Be Trained.

The traffic problem, its factors, and its techniques are so new that specialized training is essential. There is so much to be learned that this is a full-time professional job. Obviously the best work cannot be done by someone in another field who takes on traffic engineering as a side line. The following is a recommended procedure:

1. **Employ Graduating Engineers.** Select several civil engineering juniors from colleges each summer to work on a temporary tryout basis with promise of a permanent job at the end of the summer to a certain number of those who graduate with honors. This will feed in at the bottom of the highway department the brightest young men available and provide a nucleus for more intensive training after they have had sufficient experience in the department to prove their potential value.

2. **Need for Trained Traffic Engineers.** Because of the rapidity with which our modern traffic problem has developed, most highway departments have found themselves inadequately staffed with men specially trained in the dynamics of controlling modern high-speed and heavy-volume traffic. This is not a reflection upon the older men; it indicates that they have been so busy with one phase of the problem that they have not been able to devote time to the newer, increasingly important phase. This means that every department should develop a specific training program aimed at three goals:

(*a*) A year's intensive training program for the department members that are to head up the traffic engineering division. In a large state this would probably mean, over a period of years, from ten to twenty men, including the district traffic engineers.

(*b*) The training of perhaps forty "second-line men" through a two-week intensive traffic engineering training course. These men must be competent to follow the instructions and orders of the heads of the division.

(*c*) A relatively brief course for a typical cross section of all the engineers in the highway department, to give them an appreciation of traffic engineering activities and to make them more sympathetic toward the activities of the newly formed traffic engineering division.

3. **Graduate Traffic Engineering Courses.** These courses, such as those of the Yale University Bureau for Street Traffic Research, are de-

signed to train men of such calibre as to be the heads or assistant heads of traffic engineering divisions as required in section (*a*). These courses, totaling more than 2000 hours of work, require a man of considerable intellectual capacity and an ability to work hard and long. It is hoped that the students taking these courses will eventually grow to be leaders in highway departments.

4. University Courses. Several universities give courses in traffic engineering. The advantage of having personnel trained in such courses is obvious. Among the universities which have given courses having a direct bearing on traffic engineering are the University of Michigan, University of Illinois, Massachusetts Institute of Technology, Rutgers University, Brooklyn Polytechnic Institute, University of Wisconsin, Missouri School of Mines, State College of Washington, University of Pittsburgh, and the University of Utah.

A great many universities cover some phases of traffic engineering in their regular courses in civil engineering.

Naturally there are innumerable courses in collateral fields which are of great value to the personnel in traffic engineering. More important among these are:

Civil engineering.	Political science.	Public speaking.
Planning.	Public administration.	Public relations.

5. Short Courses in Traffic Engineering (Two Weeks). The primary function of this short course, as indicated in section (*b*), has arisen from a strong demand over a period of years from older men in highway departments, who, because of large families, financial limitations, or lack of an engineering degree, are unable to qualify for the full-year course. The course is equal in time to a single one-semester course at a university. It undertakes to give the student a complete appreciation of what traffic engineering is, a thorough knowledge of the tools of the traffic engineer, and an acquaintance with the process and methods of utilizing these tools. The Bureau for Street Traffic Research offers such a course as a part of the National Institute for Traffic Safety Training. The course is presented by the four senior staff members, and each student is provided with a comprehensive outline. The highway departments that have derived most benefit from these short courses are those that have sent to the school simultaneously either: (*a*) the men whom they propose to make district traffic engineers, or (*b*) a cross section of their department, with representatives from:

1. Construction department.
2. Maintenance department.
3. Design department.
4. Bridge department.
5. Administration department.
6. Landscape department.
7. Research department.
8. Planning survey department.

The cost, when the men travel by state automobile, is very low. With a tuition of $20 and traveling expenses of $30 to $50, the over-all cost per man is between $50 and $70. The actual cost per student to the bureau for staff time, expenses, and materials is probably $150. In past years the majority of the students in the short courses were kept on the payroll by their departments and had their expenses paid. Some men in other departments have come on their vacation period with or without expenses paid. Thus far approximately 200 men have been trained in the short courses of the bureau. These short-course graduates are considered in the same light as are the one-year-course alumni, and receive, from time to time, various materials on traffic engineering from the bureau. These men form a relationship with men from other departments, and exchange problems and information to mutual advantage.

The Extension Division of Rutgers University also gives a short course in traffic engineering.

6. State Highway Department Traffic Engineering Course. This course has developed as a result of the increasing feeling among highway engineers that every engineer in their department should have an appreciation and an understanding of traffic engineering as a new phase of operation into which highway departments of necessity have come. This fulfills the requirement of section (*c*). The number of these men, and the fact that they must stay close to their daily routine operations, make it impossible for them to undertake either the long course or the short courses of the Bureau for Street Traffic Research.

A type of training program to fit these men was pioneered by the Highway Engineer for the State of Nevada. He established a budget of $1000, plus funds for the traveling expenses of the instructional staff. The Bureau for Street Traffic Research was requested to organize and teach the courses. The plan entailed a three-month course during which the classes were held from 8 to 10 each morning. Thus the men were taken from their day-by-day work for only a short time in the morning. They were willing to do their study and outside reading after hours in the evening. The Bureau sent one of its assistants to cover the first two months of this course, and the associate director undertook the second month. The services of bureau staff members were handled on a consulting basis. Shortly after the course, the bureau was informed by the highway engineer that he had immediately

detected an improvement in the reports sent to him by his assistants. It is probable that similar local institutes will be held in other states.

It is a question whether it would be more advantageous to hold a three-month course, which is much more difficult to staff from the outside, or a two-week intensive course. The choice would have to be made in accordance with local conditions.

When a state has a man at the head of a traffic engineering division who has been trained through the bureau's long courses, he would be perfectly competent to be placed in charge of such a school. If he has adequately trained assistants, they too could carry a good deal of the course work. However, there are several advantages in obtaining outside specialists as the mainstay of any such school:

(*a*) The national professional reputation of the outside lecturer provides additional stimulus and interest.

(*b*) The large experience of an outside lecturer contributes a great deal under conditions in which local men may be restricted because their experience has been limited to their own state.

(*c*) The outside specialist is an effective teacher and lecturer. Some excellent local traffic engineers know their subject thoroughly, but have not had experience in presenting their materials. Under these circumstances the students will benefit very little from their lectures.

It should further be possible for a state conducting such a school to obtain the services of traffic engineers of other states.

It is also suggested that a department undertaking such a course invite engineering representatives from all cities and towns to attend. As has been pointed out, more and more the state highway problem is complicated by problems growing out of the points at which state highways impinge upon local jurisdictions. It is therefore important to the state to have trained traffic engineers in each city of any size, to have the city engineers of the smaller communities possess a sympathetic understanding of traffic engineering, and to insure that all engineering departments of cities and towns have a pleasant feeling toward the state highway department. Great public-relations values can accrue from such a working relationship.

PART THREE

FITTING ENGINEERING TO THE DRIVER

CHAPTER VIII

BRIDGING THE GAP BETWEEN THE DRIVER AND THE HIGHWAY

Once the problem of traffic has been properly defined, government reorganized to deal with it efficiently, administrative processes worked out, and men specially trained to handle it, the next step is to study the relationship between the tools of the engineer and the person who is to use the facilities which are to be provided.

Whereas numerous phases of engineering are primarily structural in nature and are thus concerned chiefly with structural design, strength of materials, static loads, etc., traffic engineering is primarily interested in the final effect and utility of engineering factors as they are used by the motorist.

Hence the traffic engineer must begin his work with a careful study of human nature. If his design and control do not fit human nature, then, as a practical matter, his facilities are a failure. Under such conditions, the customer has, in effect, bought a facility which he cannot use efficiently or safely. The impact of this curious situation on the engineer is formidable. He now finds that in order to be a successful engineer, he has to know almost as much about psychology as he does about engineering.

It is immediately apparent that the facility must be adapted or adjusted to the driver. He has certain specific abilities and these abilities have limits. These abilities, under normal conditions, are definitely affected by how the person feels and what he is thinking about. Furthermore, the person's willingness to use these abilities may be greatly reduced by the "cussedness" of human nature. The engineer may not like the behavior of the motorist, but his job is to do engineering things which will be as successful as possible in spite of this behavior.

It should be pointed out that, though there are a great many unknowns about the driver, this does not mean that he cannot be measured. He can definitely be measured through his performance, and thus, over a period of years, his actions can be accurately predicted. The measurement of the driver is undoubtedly much more difficult than the measurement of ma-

terials, but in general the same scientific procedures will produce the necessary answers.

What are the specific characteristics of the human being which place definite limitations upon the work of the traffic engineer?

The basic thesis of this part is that facilities are built for the use of people. The degree of their practical usefulness will be determined by the value of the time they save, losses in terms of accidents and congestion, and the cost and upkeep of the facility. The provision of sound economic structures is not enough. The structures and appurtenances must be humanized in their effect. This fitting of engineering to the driver is the most difficult task of the engineer.

Human factors are taken up in four groups. The first, specific human abilities and their limits, indicates the "human load," stresses, strains, limits, etc., which are the counterpart of the physical load of vehicles, their weight, and performance characteristics. The roadway was originally chiefly concerned with the physical load. It has largely solved this problem. It must now strive increasingly hard to solve the human load problem. The second group, reduction of human abilities, shows that the engineer cannot rely too strongly upon the abilities which human beings are known to have because these are reduced by other human elements. The third group, " 'cussedness' of human nature," shows that the abilities of the individual lose still more through the competition of other conflicting desires. The fourth group shows that the motorist's abilities are now in a more difficult position than they were in the earlier days of bumpy roads and poorer cars.

Starting with a fixed limit of human abilities, lowered by other elements, the engineer is faced with the problem of humanizing engineering to make facilities operate effectively under the residual human abilities that are available.

Principle 26

HUMANIZED ENGINEERING IS REQUIRED. All Traffic Design Must Be Adapted to the Average Driver and the Average Pedestrian. In Any Proposed Design the Question Must Be Asked—"What Will The Average Motorist Do?" Not "Can He Use It Properly," but "Will He?"

The most difficult task of the traffic engineer is to measure and anticipate driver actions. Good design must be molded about the human characteristics of the average driver.

One of the most fundamental factors in the traffic problem which has not received sufficient consideration in the past concerns the human characteristics of the "average" motorist and the "average" pedestrian. In too many instances the traffic administrator is quite likely to make the mistake of thinking that any design or system which he understands will be successful when utilized by average drivers. Generally speaking, traffic plans for the future must be simpler than they are today if the average motorist or pedestrian is to be expected to utilize them effectively. Some students of the traffic problem have still to recognize the fact that the fundamentals of human behavior are far-reaching and that they produce reactions to every step taken toward improved traffic control. Hence every remedial measure must be carefully evaluated in the light of these factors in order that some measure of its final effect and success may be calculated. The following human elements are believed to be important among those having a specific relationship to methods affecting the safe and expeditious movement of traffic:

1. Specific Human Abilities and Their Limits.
   - *a.* Reaction time.
   - *b.* Number of movements a person can perform. Span of comprehension. Observation power.
   - *c.* Instinct to duck when threatened.
   - *d.* Aiming in driving.
   - *e.* Limits of vision.
   - *f.* Limits of judgment.

2. Reduction of Human Abilities.
   - *a.* Fatigue.
   - *b.* Distraction.
   - *c.* Habit.
   - *d.* Illness.
   - *e.* Over-concentration on the wrong thing.

3. "Cussedness" of Human Nature.
   a. Laziness (straight-line instinct).
   b. Speed inertia.
   c. Selfishness.
   d. Exaggerated aggressiveness.
   e. Habit inertia (change in design) (change in movement).

4. Existing Human Abilities Have Been Reduced by:
   a. Removal of indices of speed (bumps, rattles, wind-noise).
   b. Reduction in time by increase in speed.
   c. Inattention.

PRESENT OPERATING CONDITIONS ARE TOO COMPLEX FOR AVERAGE DRIVERS. The Major Portion of the Accident Situation Is Not Caused by Incompetence or Malice upon the Part of the Driver, but Results from the Inability of the Driver to Make Safe Adjustments under Existing Maladjustments from Which All the Problems of Congestion and Accidents Arise.

The answer to improved transportation does not lie in blaming the motorists. Forcing their speed to a lower level in the name of safety produces poorer transportation. Improvement can come only through improving the roadway to such a degree that reduction in speed is not necessary for safety.

Experience shows that, whenever a situation has become too complex for human beings, costly human failures result. Since these failures have been human in character and in most cases unpreventable by education, they must be assumed as a constant. The answer cannot lie with changing human beings. It must, therefore, lie in simplifying the situation to a point where the individual can handle it safely and expeditiously.

If it is assumed that there is no malice on the part of the motorist, the very occurrence of accidents becomes concrete proof that present operating conditions are too complex for him to handle.

If the above reasoning is acceptable, it becomes apparent that laws and their enforcement, as well as mechanical control and design, must be vastly simplified as a basic condition for improvement.

The desire for mobility cannot be permanently suppressed by law enforcement, nor can people be educated out of their desire, as long as a marked maladjustment or differential exists between the potentials of the car and those of the roadway. Temporary gains may be made, but in the long run human nature and its inherent desires will win out, and accidents and congestion will continue until the system has been properly balanced. Though education and enforcement are essential, permanent improvement and progress can come only from a deeper consideration of the transportation system as a whole and a balancing of the factors.

By a process of elimination, therefore, it appears that ultimate success will come only through the provision of facilities which are as automatic as possible, which require few critical decisions, and upon which critical acts are practically impossible. This, then, should be considered as a final theoretic objective, even though it may not, owing to economic conditions, be achieved under all circumstances.

CHAPTER IX

SPECIFIC HUMAN ABILITIES AND THEIR LIMITS

Under this heading will be discussed the abilities and limitations of the human machine. There are seven specific points. (1) Physical and mental limitations are definite, and the facility should not rely upon them for improvements. (2) The individual cannot keep track of many conflicting movements. (3) Reaction time has remained the same as at lower speeds and is increasingly critical at higher speeds. (4) The driver can observe only just so much while driving. (5) Fear of accident will cause motorists to steer away from hazards. Thus fixed objects must be kept from operating lanes. (6) Automobiles are unconsciously aimed to follow alignment. Thus alignment must be controlled to steer the driver. (7) Judgment at the wheel is not so high as considered judgment in the office or at home. Facilities must operate under this lessened judgment.

Principle 28

MOTORISTS HAVE DEFINITE PHYSICAL AND MENTAL LIMITATIONS. Higher Speeds Give Less Time for Solving Each Problem as It Confronts The Motorist.

As speeds increase, design must rely less and less on human nature because its mistakes become more critical.

The limitations on reaction time and on eye and hand coordination must be recognized. Design must take these into consideration and must provide roadways and vehicles within the reach of limited physical powers. For example, the approach to an intersection must be provided with adequate signs, markings, and signals which will register upon the human mind a sufficient distance in advance to make it possible for the average driver to decide upon changes in operating movements which are required for safety at that particular point.

The apparent (at least to the highway engineer) "dumbness" of the motorist cannot be overemphasized. If a motorist will turn up an alley because the state route arrow showing a turn at the next corner happens to be mounted on a post near the alley, he may be expected to do anything. Every highway engineer knows that mistakes of this kind are constantly taking place.

Since it is anticipated that speeds higher than those commonly prevailing, such as 70 miles per hour, are definitely contemplated, and since the human being is not likely to change much in the next few centuries, the critical point of his limitations *today* must be given very serious consideration in designing roadways. If this is not done, these higher speeds will, without question, materially increase the number of accidents.

At the present moment, the most specific application of this principle has to do with the approach to hazards. The more rapid the rate of this approach, the better must be the design and control methods so far as their ability to offset human limitations is concerned.

The human being is such an intricate and coordinated machine that only his simplest reactions can be assumed. These, along with his greater complexities, must be measured and evaluated by research. Merely setting up a new sign on the roadway and "seeing what happens" is not satisfactory; furthermore it may cause accidents or near-accidents which will result in undesirable public relations. Fundamental research under controlled conditions must come first. This should result in new designs and devices whose rough edges may be corrected upon the highway itself.

Naturally, it will not be possible completely to "outwit the half-wit," even though this should be the basic objective of the engineer. However, the results of errors due to human limitations can be markedly reduced by requiring less of the driver, by making some types of error impossible, and by reducing the seriousness of the consequences of a mistake.

THE NUMBER OF POTENTIAL CONFLICTING MOVEMENTS WHICH THE OPERATOR IS REQUIRED TO WATCH, MEASURE, AND AVOID SHOULD BE KEPT TO A MINIMUM. The Standard Intersection Is the Scene of Numerous Accidents; It Is a Fair Assumption that Even This Number of Conflicting Movements at Intersections Is Too Great for the Average Motorist under Ordinary Circumstances.

At the ordinary regular intersection a vehicle attempting to go straight through is confronted with four potential direct crossings, two merging movements and two pinching movements. This gives a total of eight potential accident movements.

Operators do not desire to have accidents, and each operator tries his best to avoid them. Hence the conclusion can be fairly drawn that, since many accidents occur at these simple intersections, the eight movements are too much for many operators under many conditions. If this is true, every effort should be made to reduce the number of potential conflicts. As the number of entering streets increases, the number of these conflicts also increases.

Exposure of Increased Potential Conflicts Should Be Measured. It has been noticed that, as the intersection is widened, the area of potential conflict increases. This, in turn, increases the number of points at which one particular conflicting movement may take place, thus increasing the total number of potential conflict points. It is interesting to note that Y intersections and one type of double-offset street doubles the conflicts involving left turns.

The total number of conflicts for any given type of intersection having been established, it is possible by making a volume count to determine the total number of potential conflicting movements occurring in a year. This figure would indicate the relative exposure for the year. Obviously, the greater the relative exposure, the more opportunities there are for the motorist to have an accident.

It is reasonable to assume that the average driver is able to get by just so many potential conflicts before a human error will force him into an accident. Thus, if it were possible to determine the average motorist's expectancy, and if the number of conflicts during a year were known, an expectancy for accidents could be developed. This principle could be proved by measuring a large number of intersections and placing them in the order of the largest number of potential conflicts per year and also their yearly accident rate. If the intersections having the highest number of potential

conflicts produced the largest number of accidents, it might be possible to develop a formula that would indicate that relationship. With a sufficiently large number of intersections and over a sufficiently long period, other variables could probably be ironed out.

This "conflict-exposure" meter principle, if successfully developed, could be used to measure the accident expectancy of different types of intersections and to compare intersections having other variables.

It is quite likely that the exposure may turn out to be the most fundamental element affecting the volume of accidents. This proceeds on the assumption that the more opportunities there are for motorists to have accidents, the more accidents there will be.

CHAPTER X

EXPOSURE MEASUREMENTS OF POTENTIAL CONFLICTS

Principle 30

REACTION TIME OF THE MOTORIST IS MORE CRITICAL AT HIGHER SPEEDS. Every Human Being Has Definite Reaction Times. These Have Remained the Same as They Were When Speeds Were Ten and Fifteen Miles per Hour. As Vehicle Speeds Increase, Time and Space Allowances Must Be Made to Compensate for Reaction Limitations.

The time it takes for the motorist to react to something will naturally vary with the complexity of the stimulus. If a driver is expecting a change in the color of a traffic signal his time in reacting to the change may be as fast as 20 hundredths of a second. It may take another 20 hundredths for him to convert this into the action of moving his foot from the accelerator to the brake. The distance which a car travels in this 40 hundredths of a second must be added to the braking distance to determine the total stopping distance. It must be remembered, however, that this reaction time is in response to a known anticipated stimulus.

When the presence of the stimulus is unknown, it must be separated from numerous non-traffic stimuli, and when there are several traffic stimuli to be collected and sifted in the mind, and further when a choice of several different actions has to be made, this total reaction-thinking-reasoning-acting time may run as long as 3 full seconds. Three seconds for perception time at 60 miles per hour is 264 feet. If a stop is to be made, approximately 248 feet must be added. This means that a total distance ahead of 512 feet is required for the 60-mile-an-hour motorist to notice a hazard, decide to stop, and be able to stop before reaching the hazard.

This fact assumes that the motorist does not have too many other distractions and that he does not fumble in his thinking. It does not provide any safety factor.

Thus for new designs, and to allow for a safety factor, a distance of 1000 feet is recommended. This means that when the motorist is still 1000

feet away from any hazard, such as an intersection, a curve or a hill, he should get the messages to tell him what he should do, by signs, alignment, sight distance, etc. If he is nearer the hazard than that point, he may find himself too near to be able to stop.

This naturally places a very great premium upon the legibility, attracting power, and understandability of signs, signals, islands, and roadway design.

If the design and the controls are not adequate for the speed reasonably to be expected, then accidents will happen. If traffic is slowed down to fit the design, then the roadway's efficiency is reduced and complaints will increase. If police coverage is not adequate, a satisfactory speed reduction cannot be produced; besides, it may cost considerable to get more police. If this cannot be done, then changes in the design and controls are essential. From the future efficiency of the roadway these elements must be "factored up" to meet the design speed of the other elements of the highway.

The fact that the reaction time of the motorist is more critical at higher speeds does not mean that motorists must drive more slowly in the future. It means that the design must be improved if automotive transportation is to improve. It is true that under many circumstances this will cost more money. But it is likewise true that the resultant saving in time and money may be greater than the additional cost.

Principle 31

THE POWER OF OBSERVATION OF THE AVERAGE MOTORIST IS LIMITED. Good Traffic Control Should Present the Motorist with One Idea at a Time.

The average motorist has too many other things on his mind besides driving to warrant presenting to him complicated traffic situations.

There is a very strong demand, therefore, for increasing simplicity of design and control, so that the motorist may not be called upon to make decisions and solve numerous problems as he drives along the highway. Non-standard signs, markedly different operating requirements, and different problems of a complex nature at each intersection will prove too much for the average individual. It must be recognized that there is a considerable difference between what the individual is capable of doing, if everything else is taken off his mind and he is doing a specific task, and what he may be expected to do under normal operating conditions. If we are to obtain success in control measures to any considerable extent, the burden of causing changes in movement must be placed upon design and mechanical control and not too much upon the ability of the average driver to be a Sherlock Holmes in ferreting out the answer to complex traffic situations.

Notice of any possible conflict must be given well in advance to allow the driver time to reach a safe conclusion.

The power to observe must be assumed to be a specific factor with a considerable influence on traffic control. Unless this factor is taken into consideration, highway control will probably be beyond the comprehension of the average driver.

The first step in alleviating this situation is to reduce the number of items which it is essential for the operator to observe in the normal course of his driving. The fewer the observations he is called upon to make, the fewer opportunities will there be for him to fail to observe and thus to come to grief.

With the number of things to be observed reduced to a minimum, the next step is to increase the ease of observation of the remaining factors and to increase the distance at which they cannot help but be observed. To accomplish this in full will require an increase in the size and effectiveness of traffic control devices which may appear astounding to most engineers at this time. Nevertheless, the fact remains that, unless such control devices are observed, serious accidents will continue. Furthermore, money spent on mechanical controls which cannot be seen is wasted.

Analysis of sample driving situations will show many of them to be surprisingly complex. As the motorist approaches any given intersection, for example, he must first recognize it as a certain type of situation. He must next classify it as a particular problem. He must solve this problem and come to a decision. Since the problem may have in it several other moving cars and persons, it will continue to change as he approaches it.

Bridge abutment presents a grave hazard.

Thus he frequently makes one decision only to find that new conditions force him to alter his first decision. From this simple analysis it is easy to see that every advantage is to be gained by presenting the motorist with not more than one idea at a time, and arranging the control devices and the design to do this as far as possible.

Principle 32

IT IS HUMAN NATURE TO SHY AWAY FROM HAZARDS. Motorists Will Sheer away from Fixed Objects along the Edge of the Roadway. Thus All Fixed Objects Must Be a Considerable Distance from the Edge of the Pavement if Lanes Are to Be Usable.

Motorists traveling at ordinary speeds will not drive close to any vertical curb, abutment, wall, or other fixed objects, but will sheer away from them to varying distances. If there are fixed objects on both sides, the motorist indicates a marked tendency to reduce his speed, because he feels shut in. For this reason adequate optical clearance must be provided if vehicles are to keep within their lanes.

Bridge abutments immediately adjacent to the edge of the pavement furnish one of the most common examples of this principle. It can be readily noticed by observation and by oil patterns that motorists shy away from such a hazard. Since abutments are usually opposite each other, the tendency is to force cars toward the center of the road where head-on collisions result.

Another common example is to be found wherever a car is parked immediately adjacent to the edge of the pavement. Here the fear of hitting the parked car is aggravated by the dread of having a pedestrian come out from behind it.

The presence of a refreshment stand too close to the roadway will frequently drive vehicles away from the edge of the pavement.

Even when there is no hazard which might produce a collision, motorists will shy away if there is any threat to their security. For example, motorists are reluctant in rainy weather to drive too near the edge of the pavement where the shoulder is composed of mud or of soft grass or alongside high narrow fills or narrow shoulders. Naturally the amount of dodging or shying is affected by the speed of traffic and the relative hazard.

One of the chief advantages of placing lanes between islands is that the motorist will have less occasion to sheer away and the amount of his sheering will be held within fairly safe bounds.

The examples cited make it apparent that the motorist does require a certain amount of "elbow room," and if he is not provided with this in the original construction, he will make it for himself by moving over. When he moves over he is frequently so placed on the roadway as to constitute a hazard to other traffic. Every situation that causes this maneuver contributes to the waste of several feet of road width.

PRINCIPLE 33

AT HIGH SPEED AUTOMOBILES ARE AIMED RATHER THAN STEERED. Aiming or Steering Will Follow Alignment; and Alignment Must Always Be Made to Lead the Motorist in the Proper Direction.

This factor stresses the necessity for proper location of pavement edges, paint lines, guard rails, fences, shoulders, cuts, fills, and all buildings adjacent to the highway.

A lateral movement of any motorist upon the highway is affected by the alignment of curbing, edge of pavement, painted lines, guard rails, or any physical structure. The tendency of the motorist to direct his path in accordance with optical lines is exceedingly important. Unfortunately in many cases the motorist has been led into trouble through the inadvertent appearance of the elements listed above. This sometimes happens in such a way as to cause him to select the wrong direction. This is especially true at night and when visibility is reduced by fog, rain, and snow. Hence all optical lines within the right-of-way must be carefully studied. An excellent illustration of this principle is to be found where a main highway makes a right turn and is intersected on the right-hand side by an unimportant road. If the curb return on the right is bent to conform to the curb return of this entering unimportant road, the motorist will be inclined to start to follow the curb return of the minor street and be led directly onto the point of the fork.

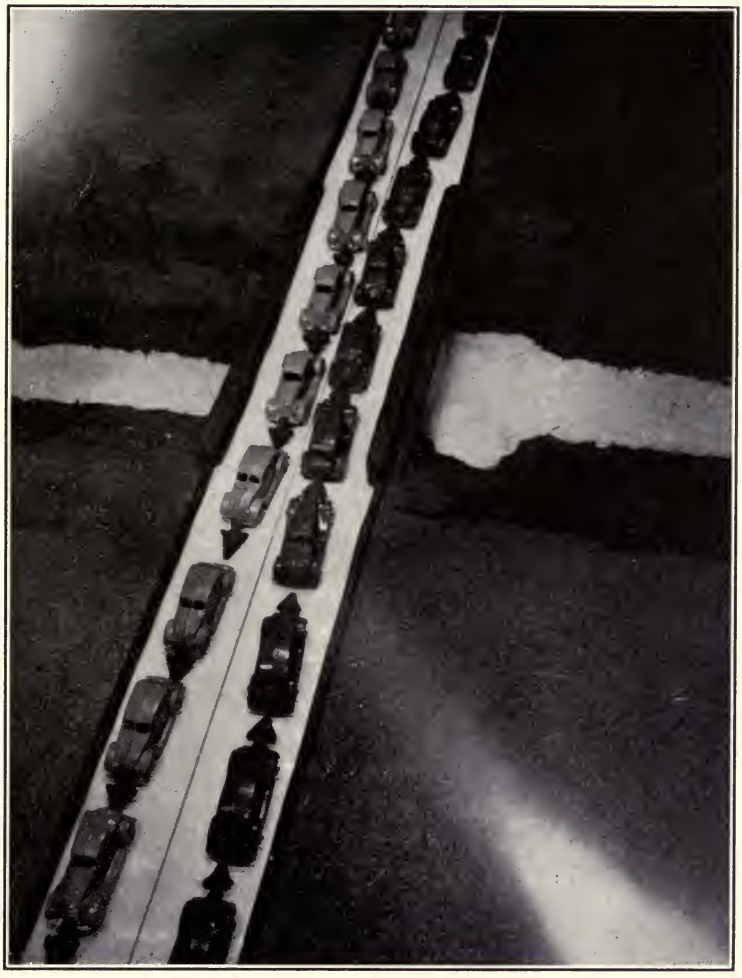
Wherever the highway follows a railroad, an interesting optical illusion is created by the unanticipated turn of the roadway around a small depot. At night, when the headlights of oncoming cars may be seen hundreds of feet ahead, an illusion is created which leads the motorist to believe that the highway is straight.

Whenever the alignment of the roadway is changed, as when a curve is straightened out, it is essential that the old guard rail be torn down or removed, as the motorist is likely to be misguided by the telltale marks of the old alignment and guard rail.

Again, wherever a medial divider is used, the divider should always follow at the same distance from the edge of the main thoroughfare. If at an approaching grade crossing over a railway an attempt is made to divert the main route slightly to the right in order to go under the grade separation, the medial divider must be slowly increased in width to follow the main flow. After the curve has been well started, the special leaving roadway for right-turn vehicles which must turn left at this point to go over the grade separation may be started. If this is not done and the roadway for the right-turn vehicles is continued along the medial divider, much of

the through traffic will follow the medial divider and find itself in the right-turn lane.

Since the principle of motorists following the alignment has been so clearly demonstrated, and since the controls are known, it is comparatively



Bryant Burkhard.

Motorists veer away from fixed objects.

easy to control the flows of traffic by highway features which appeal to the eye. The more common of these are longitudinal pavement joints, paint lines, edges of pavement, shoulders, guard rails, cuts, fills, signs, bridges, and adjacent buildings. By maneuvering these to provide consistency of alignment with that of the center of the roadway, it is possible for the road to steer a car successfully around a curve. This principle makes the natural thing the correct thing to do as far as the motorist is concerned.

AVERAGE JUDGMENT MUST BE CONSIDERED AS A RESIDUAL ELEMENT AFTER THE MENTAL ENERGY UTILIZED IN THINKING ABOUT THINGS OTHER THAN DRIVING HAS BEEN DEDUCTED. Roadways and Control Facilities Must Be Made Much More Simple than Appear Adequate to the Traffic Expert's Personal Driving Experience. The Motorist Should Never Be Given Any More Choice than Is Necessary and Never a Choice of More than Two Things at One Time.

It must be remembered that solutions deal with average judgments of average drivers. Far too frequently the traffic professional creates design or systems which appear simple enough to him from his point of view because he is so familiar with them. But they are far too complex for the average driver to understand under operating conditions. This indicates failure by some engineers to understand human nature.

In evaluating the judgment of the average man, comparisons should be made of the accuracy of his judgment in other activities of life. It would seem a fair assumption that the human being will make more mistakes while driving, because he has had less than one generation in which to become accustomed to the sensation of driving.

Since poor judgment may be assumed on the part of the driver, improvements can be brought about only by reducing the number of instances in which judgment must be employed, and by making it possible for poor judgment—further reduced by other human factors—to suffice.

An important part of the principle of the traffic signal is based on poor driver judgment. The most significant thing that the traffic signal accomplishes is to remove the necessity for judgment on the part of the operator. Without the traffic signal, the operator must decide just when it is safe for him to go ahead and when it is not safe for him to proceed. With the traffic signal, the operator is required merely to observe its simple color sequence. Traffic signals when installed under warranting conditions reduce accidents—a demonstration of the principle that reducing the necessity for judgment also acts to reduce accidents.

Stop signs are another device tending to remove judgment. By requiring the motorist to stop first, the stop sign places him in a position which allows him a moment to analyze the situation and improve his judgment. Since he is still confronted with judgment from that point on, stop signs have not been so successful in stopping accidents as traffic signals.

Slow signs also help in assisting poor judgment. Without the sign, the

operator's judgment might not be sufficiently good to bring him to the conclusion that it would be necessary to slow down. The slow sign still leaves him with the judgment of determining how much he should slow down. Thus, in order to be of greatest value, slow signs should have marked upon them the speed to which the motorist should slow down. If done consistently this would encourage use of the speedometer by the motorist. Since these speeds can be accurately determined by engineering studies and the analysis of correct speeds has been made by people of superior judgment and experience, the judgment of experts should be substituted for that of the average motorist. The speeds indicated, like all speed signs, would be taken to apply only under favorable conditions and not under conditions of ice, snow, rain, or fog.

CHAPTER XI

REDUCTION OF HUMAN ABILITIES

This chapter discusses elements that tend to reduce the normal abilities of the driver. These have been found to be lower than many engineers had assumed; even the new lower level is often further reduced by other human elements. Five factors contribute to this reduction. Fatigue, habit, distraction, laziness or a desire to do things the easy way, and an inclination to aim instead of steering the car at the point desired to be reached, thus frequently cutting corners or curves. These reductions should urge the engineer to ask even less of the driver.

Principle 35

DISTRACTION MUST BE ACCEPTED AS A COMMON DENOMINATOR OF HUMAN NATURE. Good Traffic Control Must Be Pitched at a Level Far Below That Which Would Be Possible during Concentrated Thinking.

Surprises must be removed from the highway so that the necessary activities may become more and more natural and automatic.

With numerous things upon the driver's mind, he should not be expected to apply his full intelligence to mechanical control or to reading the speedometer. The speedometer is in the same relative position as the sign and, for greatest effectiveness, should be of such a nature as to "talk" to the operator instead of having to be read. Thus special emphasis must be placed on its simplicity and clearness.

Drivers do many other things while driving besides driving. It should be assumed that every driver will be thinking about the scenery, a business or personal problem, or something else he has in mind. This may be just as distractive as conversing with another passenger in the automobile or listening to a radio program.

Distraction by competitive non-traffic signs should be given serious consideration. An advertising sign adjacent to a traffic sign and superior to it in power will receive first consideration from the driver.

Scenic points should also be evaluated carefully to make sure that as far as possible they are not encountered at times when they would be in competition with traffic control devices.

Even hazards are competitive, and in innumerable cases the motorist, while engaged in looking at one hazard, has found himself involved in an accident because of an entirely different hazard. It would appear logical to attempt to separate by time and space all individual hazards so that they might be dealt with one at a time.

If this problem is attacked thoroughly, much can be done to remove some distractions at particularly hazardous places. Where they cannot be removed they should be evaluated as a factor, and all design and control devices stepped up to have a better chance of operating in spite of them.

Principle 36

FATIGUE AS A FACTOR MUST BE CONSIDERED IN DESIGN. A Fair Percentage of Operators Will Be Tired and All Their Abilities Will Be Reduced. Thus Good Design Should Not Require the Full Alert Faculties of a Rested Person.

It has been definitely established that there is a causal relationship between fatigue and the rate of error in almost any human activity. The curves of error-frequency in numerous different types of factory work indicate the lowest error rate to be in the early morning, when workmen are most rested. This error rate climbs almost continuously until the lunch hour. Immediately after the lunch hour, the rate of error starts at a point somewhat higher than the error at the beginning of the day, but markedly lower than the level developed just prior to the lunch period, and climbs consistently until just before the close of the day, when it reaches its highest point, namely, when the workmen are most tired. It appears to be a reasonable assumption that these findings may be carried over to traffic to some extent.

It is a known fact that tired drivers do have less ability to drive safely than rested drivers, and all traffic control methods should take this into consideration. At the present time little is known of how much the driver's ability is depreciated by fatigue. The fact that numerous drivers fall asleep at the wheel, however, indicates that fatigue is a very real element.

This places considerable importance on all mechanisms of traffic control which require the motorist to notice them, to come to a conclusion, and to change his actions. It emphasizes the point that the attracting power of these devices must be so strong that the motorist cannot help noticing them even when his senses are partially dulled by fatigue.

It is quite true that a driver should not go to sleep behind the wheel, but if this results in his death with one type of design and not with another, strong efforts should be made to build the more successful type. This should not be taken to mean that the engineer should be expected to design a road that is fool-proof for those who drive in their sleep; it should indicate, however, that if certain elements can be obtained without cost, or if their cost can be justified by other factors, such elements as fatigue should be given consideration. In fact, since accident records prove that a large number of vehicles go off the road, the engineer must assume that they will and not that they will not. This means that provision must be made to make leaving the road as safe as possible. This in turn places emphasis

on removing all fixed objects for a safe distance. This distance depends upon the design speed of the roadway, upon the presence of curves, and upon other factors. Probably much can be done to relieve monotony through landscaping and through avoidance of miles-long stretches of roadbeds in prairie country, without introducing complex distractions.

Principle 37

HABIT PLAYS AN IMPORTANT PART IN DRIVING. Any Traffic Plan Which Upsets Habits Must Be Overdesigned to Guarantee Acceptance.

Any new, non-standard design which requires an unaccustomed action on the part of the motorist must be developed carefully until drivers become used to it.

Human beings are creatures of habit, and this is reflected in their driving. Most people drive from point *A* to point *B* in the straightest way possible or follow a route shown them by some friend, even though this may not be the quickest or safest way to go. If any change is made which requires a different route (such as making a street one-way), special notice is required to break this habit. Similarly, if a new roadway is created which would permit better routing, this fact must be advertised to the motoring public; otherwise the old habits will prevail and the new facility will not prove of maximum utility. This will be especially true of commercial drivers who have deliveries to make. Naturally, they are surprised and will resent anything which changes their habits. Incidentally, their job requires them to park and take merchandise into stores; if they do not, they will get fired. If they cannot park at the curb, they will double-park, and so the answer to commercial double-parking is not its prohibition, but the enforcement of "loading zones" to provide a place for such industrial activity, loading facilities within buildings, and off-street parking facilities for passenger cars.

When any new regulation or device is proposed, a careful study should be made to see what habits can be relied upon to assist in making it successful. If motorists have become accustomed to a particular sign or signal and a new one is proposed, it may have to be very emphatic to offset the old habits. Because most motorists have developed a habit of stopping at a traffic signal when the light goes red, some authorities have adopted the standard traffic signal for use on drawbridges and railroad grade crossings, thereby capitalizing on a good habit.

Thus, before any change is made, a study should be conducted regarding the present habits of operation. If these are to be upset, special precautions must be taken.

Principle 38

MOST PERSONS ARE LAZY TO A DEGREE AND ARE JUST AS LAZY IN A CAR AS WHEN NOT IN IT. Drivers Will Usually Do Things the Easy Way. Thus Design Must Make the Right the Easy Thing and the Wrong Thing Hard.

All motorists tend to take the line of least resistance. This markedly affects their behavior on the highway, and it is difficult and unwise to make them go against this feeling. For example, any road with a high crown will cause most motorists to drive on top of it for the simple reason that to drive on the right-hand side of the road is less comfortable and requires more effort in steering. Similarly, a paint line will not result in every motorist making a circuit that seems to require unnecessary effort on his part. For this reason design should make the correct driving act the easiest.

Another example of this is found in the driver who, wishing to pass cars quite frequently, tends to stay in the passing lane rather than maneuver in and out as the occasions to pass arise. The only sound cure for this is to make the outside lane more attractive than the passing lane in various ways, thereby encouraging the passer to return to the slower lane, even if for a short distance. It is unlikely that he will make the effort to pull in and out too frequently.

Drivers will, in general, pick what appears to be the easiest and most direct route. This not infrequently causes them to utilize downtown streets that are already overcrowded even when there are available circumferential routes which, although longer, would take them to their destination in a shorter time or with greater comfort. To make such routes useful, it is necessary to post them carefully and to advertise them.

The common discourteous act of cutting the corner is probably based on laziness because this direct short cut appears to be the easiest way to round the corner.

When the motorist becomes a pedestrian, his laziness becomes a different traffic factor. The average motorist will hesitate to walk much more than two blocks to and from an off-street parking lot or garage; if they are to be utilized they must be placed very close to the motorist's destination.

In many instances cars are double-parked while the motorist makes a purchase. This occurs primarily because he does not consider it worthwhile to walk a block or so from a parking space.

Trucks are frequently backed to the curb when they could just as well be parked parallel to the curb, merely because of a slight difference in the ease with which merchandise may be loaded and unloaded. In fact, many trucks are double-parked immediately adjacent to a large parking space

just because some truck driver is too lazy to maneuver his vehicle into the opening.

Thus, since indolence is a factor in the motorist, the engineering solution is to make the lazier or easier thing the right thing to do, and the violation, or the wrong thing, the harder thing to do.

In the earlier days of highway construction, before velocities had reached their present high level, the fundamental principle of design in many parts of the country appeared to be to place the operator on his own, in other words, to rely upon his instincts to cause him to slow down in the presence of danger. Unfortunately, the improvement in the car and the roadway surface considerably nullified this instinct by removing the telltales of velocity. The designer must, by other processes, make up adequate telltales of hazard.

There are excellent possibilities in the introduction of rough-pavement surfaces which will cause a considerable burr and reasonable vibration of the tires as an index of the approach to any hazard such as an intersection, curve, hill, entrances to tunnels, and approaches to traffic islands. These, by their appeal to the ear and the sense of feeling, might be valuable adjuncts to signs and markings.

It is worth noting that, as the speed indices have decreased, speeds have gone up. Since braking distances increase at a far greater rate than the normal increase in miles per hour, this situation will become increasingly critical.

Principle 39

MOTORISTS HEW TO THE STRAIGHT LINE AS THE SHORTEST DISTANCE BETWEEN TWO POINTS. The Tendency of the Motorist Is to Cut the Corner in Making Left Turns; Good Design Should Make This Impossible.

No motorist likes to go out of his way and lengthen his path merely because of a law. The only positive cure is to make cutting corners physically impossible.

Much may be learned from the fact that the shortest distance between two points is a straight line. The motorist is aware of this and will usually select such a path in his movement. This produces a reluctance to turn from a straight line, a principle that must be kept clearly in mind in designing roadways and lateral control. For example, curves on roadways and large open squares or plazas must be provided with distinct lines and channelizing islands to prevent the motorist from selecting his own straight path or short cut. Wide open squares or plazas which permit numerous choices of movement by the operator will inevitably result in a multitude of non-coordinated movements, with each operator expressing his idea of the shortest distance between two points.

All changes from a straight line require very special design treatment. Large open areas at intersections permit this human characteristic to come into play. It is so strong that physical dividers or islands are the only things which can be relied upon to prevent it.

There appears to be a minimum turn for every speed which the motorist will be willing to take of his own volition. If the curve is shorter than this he will automatically lengthen its radius by moving over to another lane. This development is particularly dangerous on four-lane highways when it takes place just as one vehicle is about to pass another. On two-lane roadways this action may also force a passing car into the ditch. This tendency urges the importance of medial dividers and of removing all obstructions into which one motorist might be pushed by another.

CHAPTER XII

"CUSSEDNESS" OF HUMAN NATURE

Whatever reduced abilities the motorist has are sometimes canceled out by his conflicting intentions. Under these conditions he may not be relied upon to use even his residual abilities to their maximum efficiency. His urge to get ahead of his fellow men is exaggerated by the power of the automobile, and he may cast aside his judgment and abilities in attempting to surpass other drivers. He resents having constantly to slow down and speed up, and will sometimes throw overboard his residual ability to measure hazard. No matter what the engineer does, he must expect that his action will produce a change in the action of the motorist. Thus the success of the engineer will not infrequently depend upon his ability to forecast what the motorist will do and make provision for it.

Principle 40

THE AUTOMOBILE EXAGGERATES THE DESIRE OF SOME HUMAN BEINGS TO GET AHEAD OF THEIR FELLOW MEN. Good Design Should Not Call upon Restraint Any More than Is Necessary.

Many motorists have a strong feeling of self-sufficiency, power, and arrogance, and a belief that everyone should get out of their way the minute that they find themselves behind the wheel of a powerful car with great acceleration and deceleration. This is quite parallel to the feeling some individuals have when they wear a badge or a uniform, or are placed in strong authority. The motorist is very likely to express this feeling through higher speeds and through a desire to pass at the slightest possible excuse or opportunity. Hence the traffic engineer should try whenever possible to avoid presenting the motorist with circumstances where too much restraint is required for safe operation. Again, he must provide opportunities to pass safely at reasonable intervals if fatal disobedience is to be avoided.

The conclusion must be drawn, therefore, that human nature cannot be expected to be as "nice" on the highway as at home or on the sidewalk—at least for some years, until driving manners have been integrated into our other social manners.

The additional pressure which results from the impact of the automobile on the character of the motorist, and produces misbehavior, will require more effective design, which is in fact physical enforcement.

Perhaps the most common application of this principle has to do with those relatively few drivers who delight in cheating a column of vehicles. This tendency may be considerably curbed by the shape of the design itself, removing the opportunity for exercising this urge.

This same urge places considerable importance upon making a careful survey of the areas and the degree of restraint. Some optimum point of restraint should be developed and strong attempts made to level off all points above this.

Principle 41

MOTORISTS DO NOT LIKE TO SLOW DOWN OR SPEED UP FREQUENTLY. They Will Try to Strike an Average Speed for All Conditions.

This principle indicates that roadways should be designed for constant speed or at least for constant-speed zones.

The average motorist is reluctant to accelerate and decelerate any more frequently than is absolutely necessary. Any system which requires a large amount of slowing, stopping, and accelerating will not prove effective. Furthermore, with a constant highway speed of 40 or 50 miles per hour, the human system becomes accustomed to that pace and is reluctant to slow down. A reduction in speed from 50 miles per hour to 35 miles per hour gives the motorist an illusion of actually driving at 20 miles per hour. Hence, provision must be made for the transition from highway speeds to city-street speed. Since records indicate that speeds are often most out of line in the transition area where highways enter residential districts, the engineer should design for constant speeds or at least for "zones" of constant speeds.

One of the present difficulties is that some speed zones are inconsistent. Attempts have been made to lay down a blanket speed zone covering an area where at some places the speed is obviously too high whereas at other places it is obviously too low. This has produced a lack of faith in speed zones. It is also true that in many instances there have been too many different types of speed zones, requiring, therefore, too many different types of speeds. The annoyance created by this has been too much for the motorist, with the result that the average motorist undertakes to create his own speed zones. A case study of these will serve to indicate the types of zone conditions which would be acceptable to the motorist.

The individual hazard seen by the motorist tends to wear off when repeated frequently. Considering this dulling of the motorist's instinct for slowing down in the face of hazards, he should not be called upon to change his pace any oftener than necessary. It would seem intelligent to reduce the number of speed zones to a smaller number, in the belief that a higher degree of observance would lower the accident rate.

It is suggested that every state make a survey of the speed zones under its present speed regulations and attempt by engineering measurement to establish a system of zones which would accurately fit each part of the highway system and more nearly conform to the practice of motorists today. Such a system would make it materially easier for police officers to enforce the law. If the zones are sufficiently reasonable and highways provide a reasonable over-all speed, such zones would eventually become more nearly self-enforcing. Speed signs would then become primarily advisory.

Principle 42

THERE WILL ALWAYS BE A HUMAN REACTION TO CHANGE. New Behaviors Must Be Anticipated Whenever Any Change Is Made in Traffic Control.

If inconvenience is increased, traffic may be driven to another street which cannot safely carry the load.

Each time a change is contemplated, considerable thought should be given to the possible reactions of the motorist. The following examples will serve to explain this point.

1. Smoother pavements will encourage higher speeds. Therefore, when a rough pavement is made smooth, control provision must be made for the higher speeds anticipated. It is dangerous to improve the surface of a secondary road without improving the alignment.

2. Installation of a traffic signal at one corner may result in the motorist's electing to detour a block to the right or left in order to avoid the signal. Care must then be taken to see that the alternate routes are protected for the new, fast movement which may result.

Even from this very brief discussion it should be quite clear that all traffic control measures must be worked out in terms of their effect upon human nature. When any change is made, all changes in vehicle operation that may result from that change must be carefully studied.

CHAPTER XIII

CHANGED CONDITIONS AFFECT HUMAN ABILITIES

With human driving abilities lower than had been presupposed, reduced by human character ailments, and further limited by conflicting intentions in the mind of the motorist, even the residual estimates are rendered less operative because of certain factors. It is harder to judge speed without bumps, noise, and vibration. Present operating conditions require a different type of quick thinking on the part of the motorist. And the attitude of motorists who are anxious to save time, having had a taste of the possibilities, makes them less reasonable and harder to satisfy.

THE MOTORIST'S MEASURE OF SPEED HAS BEEN REDUCED BY IMPROVEMENTS IN THE CAR AND IN THE ROADWAY. Whenever a Roadway Is Straightened, Flattened, or Made Smoother, Higher Speeds Must Be Anticipated.

This principle makes a tremendous change in traffic design requirements.

Most drivers are likely to determine the speed at which they operate by how much noise the car makes and how roughly it rides, instead of by looking at their speedometers and keeping their speed within the safe range dictated by traffic and roadway conditions. This is a carry-over from the old days of the model "T" Ford when at high speed the engine vibrated, the car rattled, the wind whistled through the car, and every small bump jarred the operator. Hence whenever a roadway surface is made smoother, higher speeds must be anticipated; the officer must increase his enforcement until speed is under control, and the engineer must increase his caution signs and traffic signals and improve his safety design to match the change which will take place quite naturally.

All design must assume a design speed. It further must assume that as the motorist progresses along the highway he knows his own speed and will adjust it to existing conditions. It is interesting to notice the stages of development in design speed thinking. In the first stage, before signs were erected, it was anticipated that the motorist would make his own measure of the roadway and interpret this into a safe approach speed with which his own speed would accord. Unfortunately, except in exaggerated hazards, it was found that the complexities of the roadway were too great for the motorist, and he would not come to satisfactory conclusions or take satisfactory action. Under these conditions there was no over-all design speed. Design speed was controlled primarily by the presence of physical obstructions. In the second stage the engineer tried to assist the motorist by erecting "Slow," "Curve," or "Turn" signs. These were supposed to tip off the motorist as to what he should do. Though the specific character of this type of sign was commendable, it was found that curved arrows of different radii did not convey to the motorist with sufficient clarity the differences in curves. Not being an engineer and not being especially trained to measure degrees of curvature, the motorist again was unable to interpret the indices provided. The situation was further complicated by the fact that such indices were not used consistently throughout the country.

In the third stage the engineer decided to interpret the curve in terms of

miles per hour, which placed it in the same units as the speedometer on the car. The scientific measurement of desirable speeds on curves or approach speeds at intersections has been utilized in three ways:

1. To advise the motorist that the highway department has reached a judgment as to safe speeds at particular locations and suggests that during favorable conditions of weather and traffic the motorist should adhere to the indicated speeds.
2. To advise the motorist above what speed police officers will begin to make arrests. Under a broad and vague prima facie law, such advice is appreciated by the motorist, who will thus know how the police department interprets the prima facie law.
3. To establish posted speed as a fixed speed regulation.

Under any of these three plans, the motorist may check his speed with the speed figure on his speedometer. If he does so, it will be comparatively easy for him to approach all hazards at a scientifically accurate speed.

These plans are quite satisfactory, but they make two assumptions: first, that the motorist will see the sign and agree with the figures; and second, that he will take the desired action. Certainly the attempt is sound. It must be pointed out, however, that such a procedure places increased burden on the signs. They must, therefore, have sufficient attracting power at least to guarantee that the motorist will see them sufficiently far in advance to be able to check his speedometer and reduce his speed of approach if need be. Whenever a roadway surface is made smoother, higher speeds may be anticipated; the officer must increase his enforcement until speed is under control, and the engineer must increase his caution and warning signs and his traffic signals and must improve his safety design to match the change which is almost certain to take place.

Principle 44

THE CHIEF REASON WHY PEOPLE BUY CARS IS TO SAVE TIME. It is Unlikely that Human Nature Can Be Educated, Legislated, Enforced, or Talked out of This Basic Desire. Automatic Observance of Restrictive Laws Cannot Be Expected, if They Reduce Average Speeds Which Motorists Desire to Maintain.

Every human being has a fundamental desire to move rapidly and conveniently from point *A* to point *B*. In fact, it is this desire which stimulates him to purchase an automobile. If he were not interested in speed, he could accomplish a certain amount of mobility through walking or through the use of the horse-drawn vehicle. This desire leads the driver to regard any form of traffic restriction which reduces his mobility as something to be avoided or repealed. Hence, any restriction on the driver in the interest of safety which materially reduces his mobility and, from his point of view, inconveniences him, goes counter to a fundamental desire on his part, and cannot hope for success. This makes it clear that every safety measure must also provide facility of movement.

In fact, the history of transportation since the beginning of mankind has shown consistent efforts to move persons and merchandise more rapidly. The sled, the wheel, foot power, animal power, steam power, and finally gasoline power all had as major objective increasing the speed of movement. These developments grew out of man's desire to save time.

Viewed in this light, the primary function of improving the surface of the road—getting the farmer out of the mud by creating all-weather improved surfaces—was to save time by permitting vehicles to move at all times and to move more rapidly. Now that the science of improved surfaces has advanced so far, it is no longer the controlling factor regarding the bulk of car mileage in this fight against time. The fact that the job has been solved to that extent should not mean that the transportation forces should cease their efforts—rather they should redouble them. The foundation has only been laid, and the job of building an operating structure is now before us. The vast potentials of the automobile which are now in view, and the adequate samples of what may be accomplished, should serve as a decided incentive to all engineers. This battle will always go on; it will not be finished as long as civilization progresses.

It should also be pointed out that frequently time saving is closely tied up with delay and irritation. In many cases the individual could undergo the delay without serious loss, but the delay irritates him. He would much

rather be doing something else than waiting. He is thus frequently willing to pay a toll to avoid the irritation.

Undoubtedly many persons are annoyed at the idea of driving faster to save time. They like to go out and drive leisurely at 35 miles per hour to look at the scenery and to cool off on hot summer days. However, it is probable that such motorists represent a small minority, who should be encouraged to select back roads where they will be less irritated by the majority trying to pass them. The majority of motorists who use their cars for recreation are usually anxious to get to a recreational area as fast as is comfortably possible, enjoy themselves leisurely, and then get home quickly. Thus, even in recreational use, time is the chief factor with most people.

PART FOUR

DESIGN REMEDIES

CHAPTER XIV

RELATIVE IMPORTANCE OF DESIGN

A progressive attitude is essential. The highway engineer has been forced to go through an exceedingly difficult mental adjustment. Originally he was called upon to carry out an almost superhuman task of building an enormous mileage of streets and highways to meet the ever-growing appetite of the automobile. He was faced with vast difficulties regarding strength of materials, soil mechanics, construction methods, land acquisition, the cry of the farmer for farm-to-market highways, and the political heads. The rate at which he carried out highway construction represents one of the greatest achievements the highway engineer has ever made.

At the very height of his victory over materials and structures, a brand new problem descended upon him. The roadways were clogged with too many vehicles and from the point of view of some engineers the "fools" who were driving them appeared to be geniuses at inventing new ways to have accidents. Since some engineers were brought up on construction, their natural inclination was to feel that the roadways were all right. After all, they built them and had had no trouble on them personally, and it was only natural for them to blame the motorist.

On that basis some engineers were inclined to take the position that the solution to the problem was simple enough; all one had to do was to educate the drivers and make them obey the law. This opinion was, in their minds, further substantiated when they tried progressive tactics and built what were popularly known as superhighways—wider, straighter, and with easier grades. It is easy to imagine their consternation when some of these so-called superhighways proceeded to have far more accidents than the older highways which they replaced. This certainly confirmed the engineers' opinions about motorists, officers, and educators. In all this thinking, they were reflecting their past environment and in no way should be blamed for their reactions.

At this point the more progressive highway engineer began to take stock of the situation. He began to reason that, after all, it was a curious situation that the people who paid his salary were being killed. The highway

was being built for them with their money, but perhaps it was not being built in such a way as to preserve their lives. Even with education and enforcement programs under way, motorists were being killed. Education was slow, and enforcement did not please the motorist. Furthermore, both were expensive.

The engineer began to search for the engineering reasons why the motorist—the guinea pig—had all this trouble, and to try to find the engineering solutions to the problem. He began to study the experience in factories and discovered that many types of accident were prevented by engineering guards. He then began to study what types of accidents could be prevented by design. Having found that quite a few could be, he hitched his wagon to a star and set as his final objective a type of design upon which it would be virtually impossible for a driver to have an accident. He soon found that this could be done, but that it cost a great deal of money. This only placed him in the same position as the automotive engineers, who were finding that new improvements which were extremely desirable were expensive. This did not stop the highway engineer any more than it stopped his automotive colleague. The problem from there on became one of trying to produce the same result for less money, or at a price which warranted paying for it.

It stands to reason that, if the engineer applies to the problems of safe and rapid transportation the same remarkable ingenuity that he applied to those of construction, economical highways can be built which will not have "built-in headway resistance," and which will be practically accident proof. This might be described as streamlining the highway.

The subject matter on this phase is presented in eleven topics. The first is broad and establishes a foundation and attitude. The second, functions of design, is broad but entirely within the field of geometric design. The next four, "Between Intersections," "Lanes," "Intersections," and "Traffic Islands," take up controlling principles of the different parts of the roadway. Illumination, pedestrians, and control by rule are then covered separately. The last topic describes the various ways in which the problem should be attacked. These groupings of subject matter have been selected to provide as little overlapping and repetition as possible.

Attention is now directed to those elements of design which are believed to be particularly significant and by means of which the most desirable improvements can be made in streets and highways.

THE ENGINEER MUST REALIZE THAT IN MOST PARTS OF THE COUNTRY HE HAS PASSED COMPLETELY THROUGH THE STRUCTURAL GET-THEM-OUT-OF-THE-MUD STAGE AND HAS ADVANCED TO THE NEW STAGE OF PROVIDING AN OPERATING FACILITY. The Chief Problem of Building the Roadway Is No Longer to Hold Cars up Structurally, but to Carry Them Safely and Rapidly.

Recognition of this new stage of operations is exceedingly important. This does not mean that the older stages of construction and maintenance are no longer important. Construction and maintenance will always be very necessary. But the mileage of new primary construction each year has tapered off, and the emphasis has shifted to reconstruction and the provision of important "superfacilities." The mileage of the latter, however, would represent but a small proportion of the total.

The science of construction and maintenance has reached an advanced stage in respect to structural elements. But, as operating conditions have become more complicated, the construction science in the structural sense became merely a foundation upon which to erect and mold an operating structure.

In the good-roads-movement stage of construction the basic questions were: Can the road be built, how much will it cost, and how long will it last? Now the basic question has become: how fast will the road carry the traffic, and how safely per dollar invested? This function represents the real end product of construction. The materials, drainage, maintenance, etc., are the means to the end of efficient movement. Thus it is the movement that must be evaluated, rather than the materials or their cost or maintenance. This should not be taken to mean that the cost of materials, construction, and maintenance is not important. They are exceedingly important; but the final value of the roadway must be measured in terms of the movement which it provides. This reasoning suggests a bookkeeping change which introduces traffic-cost-accounting with units of movement as economic yardsticks.

The transition to this new stage has placed a most difficult new burden upon engineers, over and above the structural and material problems they previously had. Because some of the elements of this new burden were human factors with which the engineer was not acquainted either through training or experience, it was particularly difficult for him to make the change.

With this new stage the engineer must concentrate primarily upon the operation factors. The entire automotive problem must be reduced to its operation elements and the engineering approaches molded to fit these. The science of bringing this about is in its infancy compared to the older sciences of construction and maintenance.

Bryant Burkhard.

New roads remove old curves.

The real superhighway will be found to be "super" in its functional characteristics and not primarily in its width, straightness, or absence of severe grades. Superiority in these latter characteristics as well as in its structural advantages over the older roads has been found to provide relatively little toward superiority of fast and safe performance.

THE DIFFERENCE BETWEEN THE POTENTIAL SAFE OPERATING SPEED OF THE AUTOMOBILE AND THE POTENTIAL SAFE SPEED OF THE STREET AND HIGHWAY IS ONE OF THE BASIC CAUSES OF ACCIDENTS AND CONGESTION. Human Nature Is Unwilling to Make and Perhaps Incapable of Making the Necessary Adjustments to Provide for the Present Differential.

A point has been reached where one of our greatest difficulties is the vast difference between the potential safe speed of the automobile and the highway. Common sense dictates that, with modern cars capable of safe sustained speeds of 60 miles per hour trying to operate over city streets with average safe speeds of 15 to 20 miles per hour or over highways with average safe speeds of 35 to 40 miles per hour, accident increases are inevitable. The engineer is thus forced to take the stand that, so far as economics will permit, it is the duty of design to provide a safe operating roadway with potential safe speeds in keeping with the speeds that can be obtained by the modern automobile.

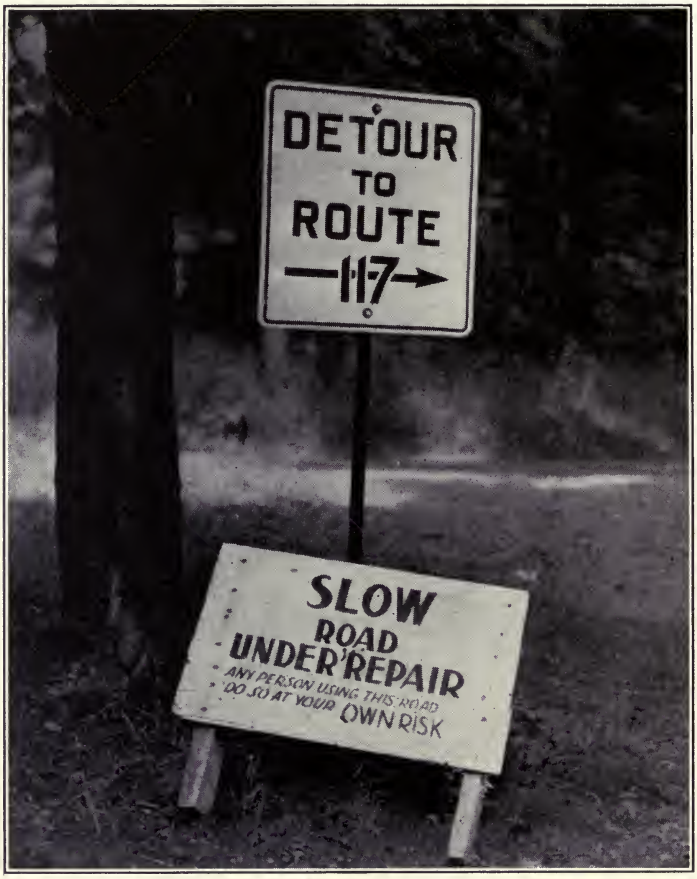
The lowest level to which the motorist's speed may be reduced is primarily a matter of human nature. At the present time most motorists have a natural strong desire to travel faster than almost all present streets and highways will permit with safety.

On many highways the car and the roadway surface will permit the driver to travel 50, 60, 70, or even 80 miles per hour. The car will take most curves and most hills with but little reduction in speed. But the functional design of the roadway will not permit this speed with safety, primarily because of the presence of other traffic. In cities the pavement, the grade, the curves, and the car, considered without reference to other traffic, would permit relatively high speed. But intersections, with their restriction on sight distance, and the presence of other traffic, greatly reduce the safe speed. Where cars are parked, the safe speed to guarantee stopping in time to avoid striking a pedestrian dashing out between two cars is probably not more than 5 miles per hour. Most traffic professionals would agree that it is practically impossible to enforce a speed limit of 5 miles per hour. A 10-mile-per-hour speed is probably unenforceable today. A 15- or even 20-mile-per-hour speed is administratively difficult to enforce. In fact, all enforcement of speeds below 20 or 25 miles per hour is so distasteful to the motoring public that it will be extremely difficult to obtain public support for a continued enforcement program.

Furthermore, the enforcement of regulations so contrary to natural

desires would be very expensive because of the heavy spread of enforcement manpower it would require.

Roadways which permit higher speeds must be brought closer to urban origins and destinations where slower speeds are necessary. Drivers do not mind low speeds over short terminal distributing runs but will not go long distances at an unsatisfactory speed.



Bryant Burkhard.

Motorists permitted to travel at their own risk.

In the end, the greatest measure of success probably will come through (1) building new facilities having higher safe speeds; (2) concentrating traffic upon a comparatively few major streets with relatively higher speeds made possible by stop signs, blocked off unimportant streets, signals, islands, etc.; and (3) reducing the number of low-speed streets used for runs of more than a few blocks.

Principle 47

ROADWAYS SHOULD NOT HAVE "DANGEROUS INTERSECTION," "TRAVEL AT YOUR OWN RISK," AND "SLIPPERY WHEN WET" SIGNS. These Signs Advertise to the Public What May Be Mistaken as Incompetency on the Part of the Engineer, Instead of Lack of Funds.

As the public becomes more interested in the safety of new highways, it becomes increasingly important that the highway department demonstrate in every way possible that it is in favor of safety. This philosophy differs decidedly from that of earlier days when the highway engineer, after providing a pavement that was structurally sound, felt that the rest of the job was up to the motorist.

Under conditions where the motorist expects safe highways and not merely structural supports, it is fundamentally unwise to utilize such signs as "Dangerous Intersection," "Drive at Your Own Risk" or "Slippery When Wet." The conditions should be corrected to make these signs unnecessary. Meantime the signs should be replaced by others not having such a negative public relations value. The best way to illustrate the impact of these signs upon the motorist is to assume that he has been traveling through numerous newly constructed intersections marked with huge "Dangerous Intersection" signs, and suddenly comes to one in front of which is a large sign saying "Safe Intersection."

If dangerous intersections continue to be constructed, and posted, the head of the highway department might conceivably become known as the man who builds dangerous intersections.

The following is an example of failure to understand this philosophy. A highway department had constructed an approach to an elevated roadway. The approach came in at right angles, making it impossible for the operator to make a right turn without swinging out into the second lane, where the bridge support on his left was so high that he could not see traffic coming. There were numerous accidents at this point. As a result of those accidents, the entrance was blocked at the bottom and a sign erected which said, "This roadway closed due to careless and reckless driving of the motorists." This obviously was transferring the fault of the design to the driver.

As speeds have increased, a new demand has been placed upon the surface of the roadway, namely, that it have a suitable coefficient of friction. Slippery pavements were not particularly hazardous at low speeds, but they certainly are at present driving speeds. The driver has come to regard a "Slippery When Wet" sign as he does a "Travel At Your Own Risk" sign—as casting reflection on the builders of the highway. Why, he asks, should

anyone build a highway which is automatically dangerous during wet weather? It is apparent that some minimum coefficient of friction should be adopted and written into the specifications.

At dangerous intersections, it would be better to use "Slow" (with stated speed) or "Caution" signs. There certainly must be legal ways to avoid suit during construction work without carrying the "travel at your own risk" connotation. The "Slippery When Wet" sign might be changed for public-relations reasons to one that would call attention to rain, snow, and ice in that part of the country.

It may well be argued as unsound policy to construct a roadway which transfers the burden of responsibility from the roadway to the driver. This statement is made with due regard for the fact that many departments have felt forced to do this because insufficient funds were provided. Even under these conditions, it is a good question whether an even stronger fight should not be made against spreading the funds so thin as to antagonize the motoring public.

The possibility of the state or the city being held legally responsible and sued is a real one in some parts of the country. This more than justifies signs to protect the department. But such signs should not carry a negative public-relations value. A suggested wording is: "The Highway Department is not responsible for temporary hazards created during construction."

Principle 48

MECHANICAL CONTROL THROUGH SIGNS, SIGNALS, AND MARKINGS IS A NECESSARY ADJUNCT TO FUNCTIONALLY INADEQUATE DESIGN. In Some Cases These Are Believed More Economical and Efficient than Control through Police Officers, but Have Definite Limitations in Terms of Reducing Accidents and Congestion.

Mechanical control devices are of very great value, but it is exceedingly important that the engineer place these tools in their proper position in respect to the entire transportation system. Far too often there has been a tendency to visualize the mechanical control tool as the end product and therefore not attempt to improve design. In reality, the true function of design is to carry vehicles rapidly and safely without the addition of any "crutches." Ideal design needs no such crutches and should continue to serve as the ultimate goal.

Control devices have great merit for certain situations. Fundamentally their function is to remove decisions from the operator, who has demonstrated his inability to make frequent decisions without error. The traffic signal and the stop sign, as well as the curve sign and speed signals, are examples of this principle. In almost all instances where errors in drivers' decisions can be removed by mechanical devices, the situation will be improved. These improvements, however, are not satisfactory if at the same time the device introduces other disadvantages which either reduce the flow of traffic or cause new hazards.

Even though the ideal would be to avoid the necessity of traffic devices through new design and to remove existing traffic devices as fast as reconstruction makes it possible, there may be some occasions in which the installation of control devices provides a more economical solution to the immediate problem than redesign of the roadway.

Mechanical devices, though valuable tools of the traffic engineer, must be carefully evaluated in terms of the conditions that warrant their use and the degree of service each is capable of performing. Any tool which is improperly used may cause considerable damage. Signs and signals installed under conditions unfavorable to their use will increase accidents. It is recommended that study be given to the values established for the control equipment, in order that the engineer may increase his accuracy in the application of his equipment. Cost figures must be obtained so that the engineer may accurately select the most economical type of control.

As superannuated roadways are relegated to secondary or distributing usage, they will undoubtedly require the services of control equipment. Since

more and more roadways will fall under this classification, and since many newer roadways do not possess ideal design requirements, the installation of traffic control equipment will probably continue to increase at an accelerated rate. In addition, numerous compromises in design will be made necessary by economic reasons. Under such conditions the control devices may be fitted into new design. It is important that new design be adjusted to bring about improved operation of all essential control equipment.

Bryant Burkhard.

This approach to a landscaped grade separation requires both a one-way and a stop sign.

It might again be emphasized that, since traffic control equipment represents the most visible of the traffic engineer's efforts, as much of this equipment as traffic conditions warrant should be used, not only for its mechanical value, but for its public-relations value as well. This latter value will be considerably enhanced if the equipment is maintained in good repair and appearance.

THE ENGINEERING PROHIBITION OF ACCIDENTS IS THE ONLY ONE WHICH WILL GUARANTEE PERMANENT RESULTS. Control Based Entirely upon Education and Enforcement Is Always Subject to Human Error.

The engineering reduction of accidents follows the experience of industrial accidents in factories where fingers, arms, legs, and heads were lost until dangerous machinery was covered up or protected by mechanical guards.

There are at least a thousand different causes of accidents. Some causes create other causes and lead to such complexities that it is almost beyond the human mind to determine upon any single cause. To cite an example: An intoxicated person driving a car at night on the wrong side of the road, at an unsafe rate of speed, with poor lights and poor brakes, collides head-on with a vehicle approaching from the opposite direction. Analysis of this accident brings out some interesting facts. The accident might have been averted if:

1. The guilty driver had been sober.
2. He had been on the right side of the road.
3. The headlights had permitted him to see, say, 50 feet farther.
4. The brakes had permitted him to stop, say, 10 feet sooner.
5. The driver had been going at a lower speed.
6. There had been a raised medial strip on the highway, forcing the driver to be on the correct side of the road.
7. The other driver had been quick enough to avoid the intoxicated driver.

Although it is true that the first five of these elements are amenable to treatment through enforcement or education, in view of the frailties of human nature the only certain method of preventing this type of collision would be an engineering physical one. The engineer who sifts through to the end causes will find that all accidents are basically caused by the four traffic frictions. These are medial, marginal, intersectional, and internal-stream friction.

Relative Cost. The cost of engineering improvements is usually computed on a twenty-year basis. Many apparently inexpensive enforcement and educational solutions may be found to be very expensive if compared with engineering improvements over a long period of years. A careful cost analysis of traffic engineering improvements will in all probability show them to be the least expensive in the long run.

CHAPTER XV

FUNCTIONS OF DESIGN

This chapter covers ten broad elements regarding the functions and objectives of design. (1) The most pressing problem of the engineer is to erect an operating facility upon the physical structure which has been largely perfected. (2) The roadway should not have surprises or conflicts which ask too much of the motorist. These should be reduced within economic limits, and the effect of their severity in the event of a mistake minimized. (3) Special care should be taken to avoid the grouping of hazards. (4) Design should require as few and as minor decisions by the operator as possible. (5) Intersections at grade are fixed obstacles to progress in time saving and accident reduction. New ones should be avoided wherever possible. Old ones should be channelized and left for distribution purposes under slow-speed operation. (6) Construction funds should be concentrated sufficiently to build optimum minimum roadways not below a level where a fair return can be had on the investment. If possible, some funds should be highly concentrated on one superfacility to be used as an example to demonstrate what the engineer can do if given sufficient funds. (7) If cruising speeds are to be efficiently maintained, the operating lanes must be protected by islands which "shadow" or protect vehicles desiring to enter or leave. (8) Increased speed has made a material difference in the rate at which design should call for lateral movement of the vehicle. (9) Mechanical control by signs, signals, markings, and islands is an integral part of the roadway and represents a very small proportion of its cost. This cost should be provided for in the original budget for any new facility. (10) An attempt to improve a congested and dangerous location by one tool of the traffic engineer should be accompanied by the application of all other tools available so as to guarantee its success.

Principle 50

THE CHIEF TRANSPORTATION PROBLEM IS FROM THE SURFACE UP. Operating Performance of the Roadway Is Not in the Subsurface but in the Supersurface Structure. Hardness and Width Are Merely a Foundation upon Which to Build an Operating Structure.

A roadway may be soundly built from a structural point of view and on an economical basis, but if it does not carry traffic safely and rapidly, it is not serving its basic function and thus is a very expensive roadway.

It is essential that all the operations of a highway department be analyzed and classified on the basis of the part they play in providing the operating facility over which the motorist must travel. The following groupings may be helpful in evaluating functional activities of highway departments:

From the Surface Down. Some of the major elements which are dealt with in the problem from the surface down are as follows:

1. Materials.
   - *a.* Concrete.
   - *b.* Macadam.
   - c. Sand.
   - *d.* Gravel.
   - *e.* Steel.
   - *f.* Wood.
   - *g.* Oil.
   - *h.* Tar.
   - *i.* Asphalt.
2. Activities.
   - *a.* Construction of roadway.
   - *b.* Maintaining roadways.
   - *c.* Soil testing.
   - *d.* Material testing.
   - *e.* Excavation.
   - *f.* Embankment.
   - *g.* Ballast.
   - *h.* Drainage.
   - *i.* Slopes.
   - *j.* Planting.

General Activities. The following are some of the activities constituting another group:

1. Projects.
2. Drafting.
3. Statistical.
4. Bridge construction.
5. Reconnaissance.
6. Location—surveys.
7. Plans.
8. Specifications.
9. Snow removal.

Land and Property. The following are some of the activities that deal with the acquisition of land upon which roadways are to be built and that control these facilities:

1. Acquisition.
2. Condemnation and excess condemnation.
3. Easements.
4. Zoning and control of access.

Traffic Engineering. The following are some of the elements which are primarily concerned with the movement of vehicles rather than the physical properties or the structure of the roadway:

1. Mechanical control.
   - *a.* Signs.
   - *b.* Signals.
   - *c.* Markings.
   - *d.* Islands.
2. Traffic design.
   - *a.* Alignment.
   - *b.* Grade.
   - *c.* Coefficient of friction of surface.
   - *d.* Illumination.
   - *e.* Sight distance.
   - *f.* Shoulder for stopping or parking place.
   - *g.* Medial dividers.
   - *h.* Rotary traffic.
   - *i.* Grade separations.
   - *j.* Elevated or depressed roadways.
   - *k.* Bypasses.
   - *l.* Routes (determination of).
   - *m.* Lane widths.
   - *n.* Accelerating and decelerating lanes.
   - *o.* All traffic movement studies.
   - *p.* Accident records.
   - *q.* Curbings.
   - *r.* Guard rails (location and type of construction).
   - *s.* Speed and delay characteristics of each roadway.
   - *t.* Design and redesign of grade intersections.
3. Construction and maintenance of traffic equipment.

Traffic Planning. The following are some of the elements of traffic planning in which the traffic engineer is much interested:

1. Population movements (dynamics of populations).
2. Gasoline consumption.
3. Business concentrations and movements.
4. Origin and destination of persons and commodities.
5. Future demands for facilities.
6. Relationship between highways and other forms of transportation.

Financial. The following are some of the financial elements:

1. Gasoline tax (rate, proceeds, equity, etc.).
2. Diversion.
3. Economic loss from accidents and delay.
3. Economic loss from accidents and delay.
4. Economic justification of new facilities.
5. Distribution of budget (state, city, highway department, engineering, traffic engineering).

Of these six major groups, the greatest immediate operating problem

today is concentrated in traffic engineering and in traffic planning. This is certainly true as far as the need for research and new developments is concerned.

It has been suggested that perhaps such a list could be used to establish an ideal percentage of the total cost of each separate service in order to form a basis for a proper budget, along the following lines:

1. Debt	——	per cent
2. Administration	——	"
3. Construction	——	"
4. Maintenance	——	"
5. Traffic engineering	——	"
6. Other services	——	"
	——	
	100	per cent

Note: The per cent figures are purposely left blank to be filled in by each department.

Traffic organizations receive funds primarily in the amount that the motor vehicle returns through taxes. To get the most efficient results, these funds must be distributed among the various services to be provided. This budget justification process is an exceedingly difficult one.

THE ROADWAY MUST MINIMIZE ALL POTENTIAL CONFLICTS. The Requirements of This Facility Must Be of Such Character as to Minimize the Four Basic Traffic Frictions.

These four frictions, in which are involved all the basic causes of both accidents and congestion, serve to clarify the situation and to provide clues upon which to base a sound engineering approach.

Bryant Burkhard.

The hill hides the intersections. Paint lines urge the motorist to move over.

Medial Friction. Medial friction takes place between cars moving in opposite directions. This results in head-on collisions, sideswipes, and rear-end collisions (produced by drivers trying to turn back into line at the last minute in order to avoid head-on collision).

Marginal Friction. Marginal friction occurs along the moving edge of a moving traffic stream. It results in collisions with parked cars, or with vehicles and pedestrians attempting to get into and out of the moving stream.

Intersectional Friction. Intersectional friction takes place between cars moving in cross directions. It results in the typical intersection accident.

Internal-Stream Friction. Internal-stream friction occurs between vehicles moving in the same direction but at different speeds. It results in accidents due to attempts to pass, and in sideswipes by those who find it impossible to pass and are forced back into the slower line.

COMPOUNDING OF HAZARDS SHOULD BE AVOIDED. Placing Two Hazards Adjacent to Each Other More than Doubles the Hazard. Hence Special Care Should Be Taken to Avoid the Placement of Hazards Close to Each Other.

This is particularly true of sharp vertical and horizontal curves. No intersection, dip, filling station, eating house, or driveway should be located just beyond a hill or a curve within the required sight distance for the 80 percentile of the approach speed. Nor should curves and hills be combined wherever the combination of sight distances causes traps or surprises.

Whenever a particular traffic situation is found to contain compound hazards, and where they cannot be eliminated, the first step should be to spread them by a distance equal to or exceeding a combination of the reaction thinking time and the stopping distance required for the design speed of that locality. This will have the effect of simplifying the control mechanisms and presenting the operator with a less complicated hazard at each point.

It is strongly recommended that every department should make a comprehensive survey of its highway system to locate all its compound hazards. In general, it will probably be found that these locations are also the high accident locations and that early efforts should be concentrated on them.

At exceedingly complicated intersections with five, six, or seven entering streets, the principle of reducing compound hazards may be applied by making some of the streets one-way away from the intersection, or by redesigning the intersection so as to create two separate simple intersections with a minimum of conflict.

In order to obtain future control over the creation of new entering roadways or entrances and exits to business establishments, zoning action is essential. It is certainly reasonable that zoning should take cognizance of the principle of compound hazards and prevent the establishment of any new business at a location where it would increase the accident hazard.

Meantime, before compound hazards can be removed, it is essential that they receive specified attention through signs and speed control.

Failing removal of the hazards, one of the most constructive steps that can be undertaken by any department is to increase the clarity of each hazard. For example, if there is a threat from cars leaving a filling station, it would be helpful to have this threat reduced to one particular opening. Again, imagine an intersection one of whose approaches is a steep hill. A traffic signal is installed at this intersection, but a special hazard develops

during inclement weather owing to the inability of cars going down to stop when the light changes color, or to the sliding downhill of cars headed upgrade. To meet this compound situation, the grade must either be set back, or auxiliary signals placed at the top or bottom of the hill, with a clearance period so arranged that once a vehicle has entered the blocked section it may pass through without interruption.

Bryant Burkhard.

A hill plus a narrow underpass plus a hidden intersection compound the hazard.

All the four frictions are susceptible of specific engineering treatment. The problem is to apply the correct treatment at the proper place and to determine a sound economic policy for providing these improvements. The normal progression of the elements of design to bring about this result will probably be as follows:

1. Determination of the desired paths, lanes, channels, or rails which cars should follow, by means of traffic studies, accident records and their analysis, planned pattern, or reasoning.

2. Signing and/or pavement marking of the plan.

3. Strengthening of the information or regulatory signing and marking by raised rubber inserts or flags at points where they will not legally or normally be run over by vehicles.

4. Further strengthening of the marking by raised buttons which add the enforcement pressure of uncomfortable bumps.

5. Full channelization of raised curbs, islands, walls, or guard-rail fences.

6. Removal of some causes of friction by:

(*a*) The use of parkways or freeways with no access from abutting property, thus removing the desire for parking and reducing the number of entrances.

(*b*) The use of full limited ways, at grade, elevated, or depressed, with no direct crossings.

If they are to be effective in reducing accidents, all these should reduce the degree of hazard to a practical minimum. This minimum must be a low enough level for average drivers to compensate for the residual hazard at each location. Anything less than this will have no effect or else its effect will be so small as to represent a poor investment.

IDEAL DESIGN ELIMINATES OR MINIMIZES ALL CRITICAL DECISIONS REQUIRED OF OPERATORS. The Design of the Highway Should Eliminate the Necessity for the Driver to Make Critical Decisions, or, if Such Elimination Is Not Feasible, Should Make it Impossible for the Driver to Make an Erroneous Decision. Furthermore, so far as This Is Impossible, the Design Should Provide Physical Protection to Reduce the Severity of the Consequences of an Erroneous Decision or to Compensate for Any Failure of Personnel or Rolling Stock.

No design can be completely successful if it fails to take into account possible errors of human nature. The best results can be obtained if driver decisions are reduced or made less critical, and if protective devices are provided to minimize the effects of poor judgment.

Eliminating Decisions. Whenever design permits the driver to make a critical decision which may result in a collision, accidents are certain to happen. After the design has been installed, it is merely a case of waiting for enough traffic movement to make a natural human error a statistical certainty. Since the frequency of such accidents will be determined primarily by the number of decisions which take place, the soundest engineering attack is to eliminate as many decisions as possible.

On the two-lane highway all attempts to pass require critical decisions. If the sight distance is unlimited, the decision whether to pass or not is easier and mistakes will be fewer. On curves and hills, where vision is curtailed, the errors will usually increase. If the highway is widened to four lanes but left undivided, mistakes are still possible. However, with a four-lane divided highway, fewer mistakes will occur in the attempt to pass because the decision is made easier by the fact that oncoming traffic does not have to be considered.

Three lanes of traffic moving in the same direction require more difficult decisions than two lanes or one lane: The driver has to look alternately on each side of his vehicle and cannot watch both sides simultaneously.

A left turn at a corner requires a decision regarding oncoming traffic proceeding in a head-on direction. A grade separation or rotary traffic circle removes this.

Prohibiting Erroneous Decisions. If, for economic reasons, some decisions cannot be eliminated, design should try to prohibit erroneous ones. Thus, for left turns, if a grade separation is impossible economically or is not warranted by the volume of traffic, left-turn islands will prevent the erroneous decision of cutting the corner in order to beat the oncoming car.

Reducing Effect of Wrong Decisions. Center supports on bridges should be eliminated so that they will not be struck by motorists who have made wrong decisions. If this cannot be done for economic reasons, a guard rail or a "parabolic divider" should be installed to make it impossible for the motorist to hit the center support even if he does make a wrong decision.

The typical guard rail on the outside of curves now serves a like function. It reduces the effect of a wrong decision, such as going into a curve too fast; the motorist, instead of going off the road into a deep ditch and having a serious accident, has the results of his wrong decision reduced by the guard rail along which he slides until his vehicle is brought under control and returned to the proper part of the highway. A gradual slope instead of a deep ditch along the road also provides safe escape in the event of wrong decision.

INCREASED CAPACITY AND HIGHER SPEED WITH SAFETY OF ANY REAL MAGNITUDE CANNOT BE OBTAINED WITH GRADE CROSSING INTERSECTIONS. Present City Street Systems with Intersections at Approximately Every 300 Feet Can Never Carry Traffic Safely Faster than about 15 Miles per Hour and with Equal Cross Flow at Only Approximately One Quarter of the Volume That Can Be Brought to Each Intersection under Maximum Flow Conditions.

This indicates why the intersection is the most malignant of traffic diseases. To attempt to improve our gridiron intersections would be to send good money after bad. Present central business district systems should, in the main, be left as they are and utilized only for local distributing systems. Increased speed and capacity with safety must be obtained through substitution of the intersection by one-way streets, blocking off of unimportant streets, rotary traffic, grade separations, parkways, open cut, full subway or elevated roadways, or limited ways.

Hence, the creation of any new intersection should be seriously questioned, and evaluated against the expenditure of similar funds for the removal of other difficulties in some more important part of the system.

Where "immediately adjacent" access is required the intersection may be necessary, but it will produce a very low speed which in spite of enforcement and education will produce accidents and a movement efficiency in many cases of about 25 per cent. Fifty per cent of the capacity is lost because only one street can move at a time, and at least another 25 per cent is lost by starting, stopping, and turning. Furthermore, the restriction on sight distance will usually reduce the safe speed far below that of other parts of the roadway.

The full costs of the intersection to the highway system are only now being appreciated. The accident and the congestion rates at an intersection are out of all proportion to those of other sections of the highway. In addition to the direct losses it produces, the intersection entails numerous other financial outlays for signs, signals, markings, and islands. Eventually, if the intersection's capacity is to be brought up to that of the non-intersection area by accelerating lanes and decelerating lanes and by traffic circles and grade separations, the cost of preserving the highway capacity by properly designing intersections would represent an oppressive overhead.

Hundreds of intersections in almost every city could be removed at nominal cost, assuming adequate legal authority. Where intersections cannot be removed entirely they may be made less harmful by means of islands

prohibiting direct crossing and permitting only right turns into and out of the intersection.

Dave Packwood.

Intersections have inherent hazards and delays.

Each highway department should make a cost study of the intersections of all proposed new developments to determine how much could be saved by reducing their number and applying modern design.

Principle 55

CONSTRUCTION EFFORTS SHOULD BE CONCENTRATED. Important Traffic Flow Should Be Concentrated upon "Quality" Roadways and Not Dispersed over Large Numbers of "Quantity" Roadways.

Since, in general, it is more expensive to construct the higher type of intrinsically safe roadway, it is advisable to concentrate highway funds sufficiently to make possible at least a few first-class highways. The bulk of travel may be carried on a few fast and safe roadways at a lower cost per car than on a multitude of highways carrying lesser volumes.

Courtesy California Highway Department.

This type of facility entails higher total cost but brings lower unit cost in time saved and accidents prevented.

With increased traffic accidents and congestion, there has been a tendency in some localities to reduce the volume by spreading it out and building more roadways or widening existing streets. Such a procedure does not take into consideration the reduced speeds and the formation of permanent bottlenecks at grade intersections already alluded to. The creation of more roadways with the same traffic disease is not a cure for the traffic problem. The better principle is to concentrate traffic on quality roadways designed to carry it safely and expeditiously.

The scattering of roadway funds produces two additional difficulties.

First, it sometimes reduces the funds available at a particular location to an amount which cannot improve the efficiency of traffic movement sufficiently to warrant the expenditure. This point may be illustrated by making the ludicrous assumption that all funds were so spread out that they would merely provide one additional traffic sign at all intersections. Even if these signs were needed at each point, the traffic conditions at many of these points would be of such a complicated nature that one sign would probably have little or no effect. If the same funds were redistributed with enough concentration to provide what a fewer number of intersections really needed, some positive results would be obtained. Many traffic problem situations

Courtesy Cincinnati Division of Highway.
Bridges must span other things than water.

will be found to have a minimum requirement. If enough funds are not available to meet this, the funds had best be spent at a point with a lower requirement.

The second difficulty of the dispersion of funds is that the taxpayers are never given a good sample of what the department is capable of doing and would like to do to provide the maximum in transportation efficiency. Without this sample, the selling of new sound traffic engineering developments is exceedingly difficult.

There are many places where, if traffic flows can be consolidated, it would prove economical to build limited ways, freeways, parkways, and elevated or depressed highways.

Principle 56

ALL VEHICLES ENTERING OR LEAVING A TRAFFIC STREAM SHOULD BE PROTECTED BY SHADOWING ISLANDS OR SOME INTEGRAL PART OF THE DESIGN. Traffic Which Is Moving Is Reluctant to Stop; Therefore Specific Provision Should Be Made so That Vehicles Desiring to Enter May Wait and Enter in a Shadowed or Protected Space until a Safe Gap Appears in the Cruising Stream.

Protection for entering or leaving vehicles is particularly essential where more than one stream of traffic is to be crossed and where gaps do not occur frequently or simultaneously.

The contrast in speed between vehicles driving at cruising speed on the highway and vehicles entering at a low speed is an important cause of accidents and congestion.

It is perhaps unfortunate that once a motorist has attained his cruising speed he tends to cling tenaciously to it. When another vehicle enters the roadway in front of him, he frequently will alter his path and possibly swing out into the opposing lane rather than slow down and stay behind the intruder.

The entering situation becomes increasingly difficult as volume increases. A point is soon reached where, with a normal frequency distribution of vehicles, a considerable time will elapse before a gap of sufficient length to permit a vehicle to enter and accelerate with safety is opened up in the moving stream. The irritation caused by the delay of waiting for such a gap frequently forces the motorist to attempt to enter the moving stream through an inadequate gap. By so doing, he often causes either a delaying jam or an accident.

Since continuous movement at cruising speed represents the most efficient process of transportation, it follows that vehicles should enter the moving stream at a speed approximating the cruising speed. This can be accomplished only when the accelerating lane is of such length as to permit the entering vehicle to accelerate to this speed. The reverse principle holds regarding vehicles turning off the main highway. If they slow down on the main thoroughfare, everyone behind will be required either to slow down to that speed or to pass. Not infrequently the irritation of slowing down will lead to hazardous passing. The solution is to provide a decelerating lane which the motorist desiring to leave the thoroughfare may use to slow down outside of the operating lane, where cars may continue at cruising speed.

Left-Turning Vehicles. Motorists desiring to make a left turn at the ordinary intersection are frequently placed in an exceedingly dangerous position. They are forced to slow down within the cruising lane, thus

causing irritating delay to those behind, and perhaps forcing human errors. After they have reached the intersection, while awaiting an opening in opposing traffic, they are often passed by vehicles on both sides. The only adequate solution of this situation is to provide a medial island of sufficient width to "shadow" completely the left-turning vehicle while it is waiting in the intersection for a chance to complete the turn. These medial islands also serve a shadowing function for cross traffic, which is thus permitted to cross one moving traffic stream at a time, without having to wait for simultaneous gaps in both directions of traffic. Without islands or separate left-turn lanes, the capacity of an intersection may be reduced 50 per cent.

Courtesy Public Roads Administration.

It pays to carry traffic over delay and accident areas.

The traffic spreaders introduced at the entrance to a rotary traffic circle should be of such design as to shadow the entering vehicle from the path of another vehicle revolving around the rotor. This shadowing will permit it to wait for an opportunity to enter, if this is necessary, and will also force it to merge at a satisfactory angle, besides controlling its speed of entrance.

When medial islands are installed and U turns are contemplated, pockets should be provided into which the U-turn vehicle may enter and decelerate, make the turn, and then accelerate.

The provision of islands for pedestrians serves similar ends by shadowing or protecting the pedestrian from approaching traffic.

Principle 57

VELOCITY ABHORS CHANGE. ANY DESIGN WHICH REQUIRES THE MOTORIST TO MAKE A LATERAL MOVEMENT AT REASONABLY HIGH SPEED SHOULD DO SO AT A RATE NOT LESS THAN APPROXIMATELY 60 TO 1. If Any Design Attempts to Produce a Lateral Change at a Greater Rate, either the Change Will Not Be Made and An Accident May Occur or the Operator Will Select a Rate of Change More Favorable to His Speed. This May Place Him on the Wrong Part of the Pavement, Which in Turn May Cause Delay or Accident.

The faster a vehicle is being driven, the harder it is to drive it around a corner, and the stronger the sensation of turning conveyed to the driver. Thus a motorist driving at a high rate of speed has a definite tendency to continue in a straight line and, as speed goes up, is increasingly reluctant to turn his vehicle sharply.

The result of this principle, based on the laws of centrifugal force, causes motorists to cut the corner at curves, thereby flattening the curve, instead of slowing down.

The same physical forces cause the motorist when taking curves on multi-lane roadways at high speed to veer into the adjacent lane in order to continue in as straight a line as possible while rounding the curve. This has the effect of bottlenecking the curve and reducing its capacity by one or more lanes.

Where an entrance to any roadway is composed of two entering lanes, this principle encourages the motorist to cut from one lane to the other, thus pinching off one of the available lanes. It also permits two cars to enter abreast, thus blocking the main roadway. The best answer to this problem appears to be to provide two one-lane entrances rather than one two-lane entrance.

Even though the motorist may desire to select his own rate of turning or lateral change, it is inadvisable to permit him to do so. Thus, for example, a square or abruptly rounded front-end of an island will permit an approaching motorist to proceed directly up to the island and then make a quick turn to avoid it, thus depositing the island in the lap of the vehicle immediately behind him. This situation also makes it possible for him to cheat the line of drivers who are properly approaching the front end of the island at a reasonable angle. For this reason the approach to the front end of an island should be constructed on an angle of approximately 60 to 1.

Naturally the rate of 60 to 1 must be adjusted in accordance with the

rates of speed for which the roadway has been designed. This rate may be determined for prevailing conditions by snow patterns or headlight pictures.

The "natural" path of the automobile driver is believed to be the best objective of all design. The farther roadway design alters its channels away from the "natural" path, the more guard rails and barriers will be required. If the channels which control the motorist fit the normal path of

Courtesy Oregon Highway Department.

Traffic streams are carried over railroad streams.

the motorist, protective mechanisms will be required only for the occasional violator.

Unfortunately, at the present time comparatively little is known about the "natural" path of the motorist, especially in terms of his unwillingness to drive close to adjacent hazards or his performance where superelevation is introduced. Additional research on these subjects would be of exceptional value.

Principle 58

THE COST OF SIGNS, SIGNALS, MARKINGS, ISLANDS, AND SAFE DESIGN IS AN EXCEEDINGLY SMALL PART OF THE TOTAL COST OF THE ROADWAY. These Elements Are Just As Important as the Structural Physical Elements of the Roadway, When Viewed from the Primary Function of the Roadway to Carry Traffic Rapidly and Safely.

Control devices and safe design should be considered an integral part of the roadway and figured in the original construction and maintenance cost budget. It is probable in many instances that both construction and maintenance budgets could be redistributed to give these operations elements a larger percentage of the funds, with the probability of effecting marked savings in time and accidents.

Almost every department has felt the difficulty of obtaining additional funds for traffic control equipment. This is doubtless a carry-over from the earlier days when the value of such equipment was questionable, and when a good deal of it, through the efforts of some supersalesmen in merchandising equipment, had been misused at locations where it was not needed and where in some cases it actually increased accidents.

The fact is that the real value of the elements listed, as measured in savings in accidents and delays, has never been reduced to dollars and related to the total cost of any particular section of roadway.

It is doubtful that the situation will be much improved until a traffic cost-accounting system has been developed and the losses and values of operational equipment matched against the over-all losses and costs of the entire structure. Whenever new construction is budgeted there should be a separate item in the total budget for traffic control equipment. In most highway construction this will be found to be such an infinitesimal part of the total cost that the necessary funds will not be difficult to obtain.

Traffic control equipment costs much less if installed at the time of new construction. For example, to lay conduits for the cables of traffic control signals when pavement has already been installed may run about $3 per foot, whereas during construction the pipes for conduits may be laid for a few cents a foot. Thus, even though traffic equipment is not installed at the time of the highway construction, it would appear to be sound policy to install pipes at a few cents a foot if there is any reasonable belief that signals may be needed within a fairly short time.

Not infrequently the installation of traffic equipment may permit the postponement of an expensive reconstruction of the intersection. A 50 per cent improvement under a restricted budget is better than no improvement.

It should be possible by introducing mass production methods in the cleaning, painting, and maintenance of traffic control equipment to reduce the over-all expense materially. The best process would be to obtain a few duplicates of all equipment and keep them in constant repair in the maintenance shop. Whenever a piece of equipment in the field needs attention, it will probably be found more economical to replace it with the repaired equipment than to attempt repairs in the field. All equipment should be maintained on a schedule basis. This would save a good deal by eliminating the necessity for special emergency trips to replace burned-out bulbs, timers out of order, or traffic signs needing repair or repainting. These individual trips are exceedingly expensive when figured on a cost-accounting basis.

It should again be emphasized that, since so many of these elements are visible in character and contain a high public-relations value, special efforts should be made to do a complete visible job. Assuredly traffic engineers would like to have the motorist when he approaches a new improvement think, "Our department certainly did a whale of a job on that intersection." Such reactions, on the part of citizens, passed around through clubs and family circles, would do much to advance the reputation of the traffic engineer.

Principle 59

THE CORRECTION OF TRAFFIC "HOT SPOTS" SHOULD BE ROUNDED OUT BY IMPROVING ALL EXISTING DIFFICULTIES RATHER THAN BY CHANGING JUST ONE ELEMENT. If Only One Element of a Bad Situation Is Changed, the Other Bad Elements May Prevent the Improved Element from Working.

If a bad intersection requires the installation of channelizing islands, a good policy would be to improve the signs, signals and markings, and the illumination at the same time. The effectiveness of the combination would be much greater than the improvement of just one element and would help build public confidence and good-will. Furthermore, the chances of success of the announced change would be much greater, and such success has a much better public-relations value than a failure of one element when it is installed.

All traffic improvements are mutually interdependent. Some improvements will not function properly in the absence of other corrections. Other improvements cause new actions on the part of the motorist which will prove hazardous unless special provisions are made.

An example of the application of this principle follows:

Under many circumstances traffic signals will not function efficiently unless stop lines and cross-walk lines are provided and adequate signs, giving advance notice of the presence of the signals or stating special movements, are installed. Stop signs very frequently are inefficient unless they are supplemented by a stop line located at the exact point where the motorist should come to a stop.

Many traffic devices which provide adequate protection during the daytime will not function effectively at night unless reflectorized signs or street lights are provided.

Naturally, almost any intersection will improve in its performance at the time any traffic equipment is installed if parking is moved back farther from the corner.

Again, artistic planting of islands or sidewalk lawns will add considerably to the esthetic appearance of the entire area.

When islands are installed it is sometimes beneficial to maintain white curbs by paint or permanent white materials in order to obtain the maximum visibility during the early stages of their use.

When a traffic signal is installed at a particularly difficult or high-speed location, special precaution should be taken to prevent the rear-end collisions which usually take place until motorists have become accustomed

to the new signal. It is recommended that specially large warning signs be posted at the start, to be replaced perhaps by smaller signs later. In extreme cases, at the time of the original installation, the four far-right corner standard lights may advantageously be supplemented by a suspended four-way center installation. This would do much to guarantee advance visibility and might aid in reducing rear-end collisions during the period of "breaking in" the motorist. Such a signal might be economically installed

Courtesy Memphis Traffic Engineering Department.

The effectiveness of signals is aided by signs, markings, and loading zones.

for a few months and, if no longer needed, removed for similar service elsewhere.

A common example of the necessity for rounding out improvements is found where smoother pavement is laid at an intersection. While there can be no argument that this is an improvement, the fact remains that it will undoubtedly increase the speed of vehicles approaching the intersection. The existing control mechanisms may not be equal to the new situation. In that case, before traffic is permitted to enter the new construction, increased protective measures must be provided.

CHAPTER XVI

BETWEEN INTERSECTIONS

This group of principles covers four elements of major importance. (1) The design values of a roadway must be protected, as an investment, by insulating the right-of-way and limiting the access by parkway, limited

Courtesy Missouri Highway Department.

Complete insulation from conflicting movements can be obtained by open-cut facilities.

way, freeway, wide rights-of-way, or guard rails, fences, or elevation differentials. (2) Sight distance on curves and hills must receive special attention if they are not to bottleneck the route. (3) All multi-lane highways must be divided. (4) The vital function of overtaking and passing must receive additional attention if safety, capacity, and time saving are to be increased.

RIGHTS-OF-WAY MUST BE INSULATED, AND ACCESS MUST BE LIMITED. The Efficiency of Original Construction Must Be Insured by Sufficient Right-of-Way Width, Creation of a Parkway, Elevated Highway, Use of Guard Rail, or Construction of Open Cut. To Accomplish in Full the True Functions of a Completely Acceptable Facility, a "Limited Way" Is Required.

A true "limited way" eliminates the four traffic frictions. It is a way on which there is no cross traffic at any point, no direct access to abutting property, a physical division of opposing lanes of traffic, and accelerating and decelerating lanes for entering and leaving. Its design is frequently, but not necessarily, elevated. Nothing is more inefficient than building a good roadway only to have its utility badly crippled by business or residential development along its margins.

As highway speeds and congestion increase, the necessity for acquiring sufficient right-of-way at the outset becomes apparent. This is especially significant at intersections, because visibility is the major factor in the safe approach speed and because additional space is necessary for turning movements and channelizing islands or for the eventual installation of rotary traffic and grade separation at the more important crossroads.

Zoning measures establishing the distance of the building line from the highway and regulating driveways to the buildings should be enacted. Small communities soon develop near the junction of important routes, and sufficient right-of-way must be available for subsequent construction of service drives and islands separating the high-speed from the slow traffic. The economic advantage of acquiring land before it becomes expensive is evident.

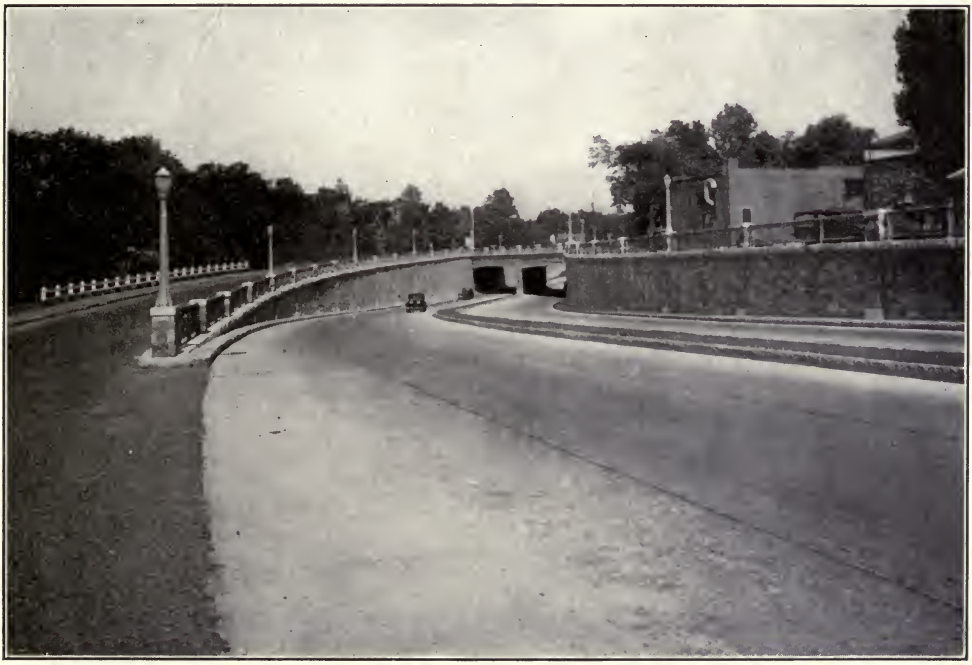
To provide safe and rapid speed, the number of intersections must be reduced, since it is not economically sound to provide grade separations or rotary traffic for all junctions.

In the long run, no highway will successfully fulfill its transportation functions until full control over its margins has been obtained. This means that either the border of the highway must represent an area of complete insulation through which no car may enter, or that any entrance provided through this insulation must be made exceedingly clear and fixed and must be rigidly controlled. Such a procedure would greatly reduce the number of potential conflicting movements—on some roads as many as 100 per mile.

Under prevailing conditions in many parts of this country, where the roadway edge is lined with filling stations, hot-dog stands, specialty shops, food markets, and honky-tonks, the motorist is confronted with a series of

potential interruptions and conflicts. If these can be brought under control and reduced in number, the chances of the motorist's encountering hazards are considerably limited—up to the ultimate Utopia wherein complete insulation and grade separations would reduce potential conflicts to zero. The following types of elements may be used to provide this all-important insulation:

Cuts and Fills. Where they must be used for construction purposes, cuts and fills or drainage ditches automatically reduce the number of en-



Courtesy Massachusetts Public Works Department.

Modern limited ways dip under village intersections.

trances from abutting property. Such roadway features must, of course, be protected by guard rail if they offer danger.

Guard Rails. Guard rails can be used to block off definite areas. If the guard rail acts as a safety device to keep motorists away from the hazard of going into the ditch, it would seem equally reasonable to utilize guard rails to prevent the motorist from being struck by vehicles leaving entrances or exits at unrestrained angles.

Raised Curbing. Curbing is of assistance in transition areas adjacent to suburban sections, as it emphasizes the necessity of obtaining permits for driveways, and this acts to restrict their number.

Parking Restrictions. "No parking" restrictions are of considerable assistance in keeping road margins clear. Vehicles leaving the parking lane immediately adjacent to a high-speed lane travel at so low a speed as to be nearly as hazardous as fixed objects. Parked vehicles reduce the sight distance, narrow the effective width, and form fixed obstacles on the sides of the road.

Wide Rights-of-Way. Extra-wide rights-of-way, 300 to 500 feet for instance, naturally give the highway department greater opportunity to control access.

Bryant Burkhard.

Fences, curbing, and guard rail keep traffic free from outside interference.

Service Drives. These may be used with insulating strips. They are useful for providing local access requirements where business structures abound, and in some places automatically prohibit parking.

Parkways. The creation of narrow strips of park on each side of the roadway may sometimes be advisable when other measures are difficult from the legal point of view. In addition to denying right of access, the parkway has the advantage of denying the use of the roadway to commercial

vehicles, pedestrains, and bicycles, and of providing an attractive environment that has considerable sales value.

Zoning. Zoning by town or county, strip zoning, or the enactment of limited-way legislation may be, in the long run, the most economical means for controlling access. This provides insulation without the necessity of purchasing large areas of expensive property.

Elevated or Depressed Roadways. The construction of elevated or depressed structures, though comparatively expensive, may very frequently be justified in urban areas. Such roadways naturally provide complete insulation.

Removing Incidence of Parking. Perhaps the only cure for parking is a removal of the incidence of parking or of those purposes for which people have the urge to park. These urges are usually of a business nature; thus if business, or access to it, is absent, there will be infrequent occasions for parking. Parking for other reasons may be adequately prohibited by reasonable enforcement.

Rebuilding. The importance of insulating the margins of roadways cannot be overemphasized. Nothing can be more futile than building a facility which originally has high performance characteristics only to have these characteristics progressively destroyed by the development of adjacent property. Building and rebuilding of a facility, sometimes as many as four or more times, represents a tremendous economic loss; and the worst part is that, with none of the above operative mechanisms in action, there is no end in sight.

Unrestricted Access. Entrance on highways will be universal unless curb, fences, ditches, or slopes are provided. Either the incidence of parking must be removed, or special parking provisions must be made at all points where there will be a natural desire to park.

Blocking off Unimportant Streets. Another method of insulating a main thoroughfare is to block off the unimportant streets which carry light traffic and are not through streets. There is no necessity, on a time-saving basis, for every street to cut across a main street. A relatively small percentage of the traffic should not be permitted to cause delay and hazard to the important traffic. The difficulties caused by these light traffic streams can be removed by such methods as the following:

(*a*) Making the streets one-way away from the main street, thus permitting no entering traffic.

(*b*) Placing a raised island across each of the entrances of the side streets, thus permitting vehicles to enter or leave by making right turns

but not permitting traffic to make left turns or to cross the main thoroughfare.

(*c*) Redesigning the main street at that point so as to remove the intersection.

In residential areas the prevention of through traffic may be considered an asset to the unimportant traffic streets.

The processes enumerated will considerably aid the flow of through traffic by the removal of interference. This is quite analogous to the railroad

Bryant Burkhard.

Cars can climb hills, but drivers cannot see through solid ground.

practice, in passing through a town, of providing bridges or tunnels for the small percentage of important streets which run across the tracks.

In addition to the traffic flow values which insulation provides, there will sometimes be esthetic values. These may be employed to advantage in selling the plan, particularly if models of it are shown. This point may serve to justify the purchase of rights-of-way wider than the operating functions of the roadway would strictly require.

THE PROBLEM OF MOST CURVES AND HILLS HAS CHANGED FROM ONE OF THE POWER TO CLIMB AND STOP TO ONE OF SIGHT DISTANCE FOR PASSENGER CARS, AND OF ECONOMICS FOR TRUCKS AND BUSSES. Modern Cars Are Not so Restricted in Their Hill Climbing and Curve Rounding as Previously, and Will Outrun Sight Distances unless the Design Speed of the Curve or Hill Is Fairly Near That of the Level Straightaway.

Motorists traveling long distances soon strike a pace which they try to maintain regardless of the visibility at each point. As it is exceedingly dif-

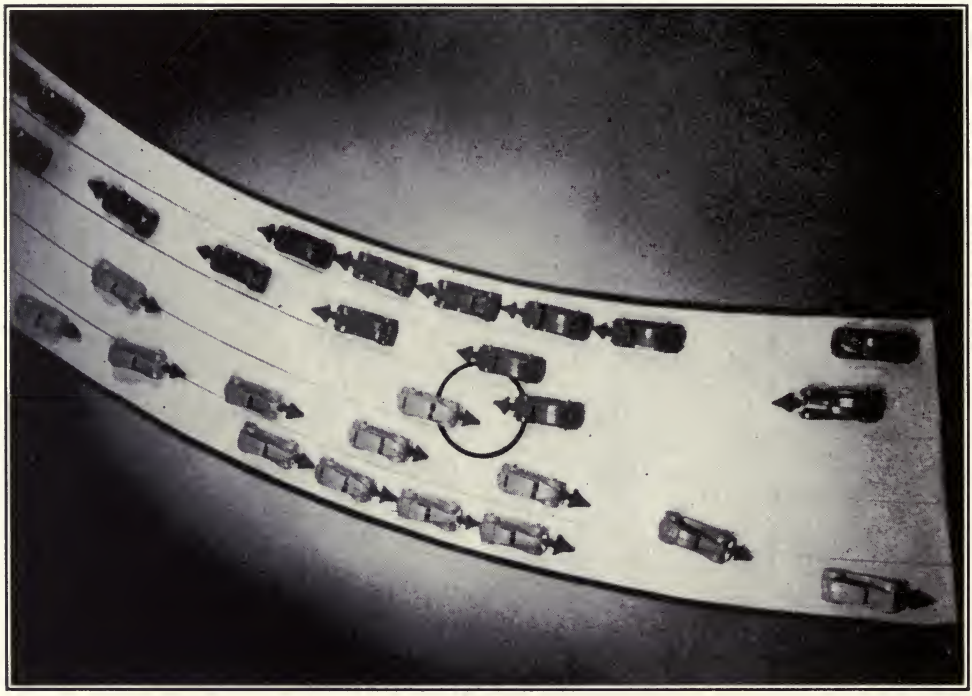
Bryant Burkhard.

Schematic island permits passing on hills.

ficult to make the long-distance or touring motorist slow down, curves, hills, intersections, and other points which require reduced speed for safe operation should be improved so that their safe approach speed is not much below the safe speed of the rest of the highway. It is just as important to consider the visibility at a curve or a hill as it is to consider the speed at which the

car is capable of negotiating it. The ultimate limit of safe top speeds will probably be sight distance. The sight distances which can be afforded will probably limit the height of safe top speeds.

Of course, where the highway is made up of a succession of curves and hills, it would be poor policy to attempt, by altering these, to bring the highway up to modern standards. It may be less expensive and more satis-



Bryant Burkhard.

"No man's land" lanes cause difficulty in passing.

factory to leave the old road for slow local traffic and build for the new requirements on an entirely new location.

The operating characteristics of passenger cars and trucks require provision for passing, if the efficient speed of each type is to be maintained. The economics of providing either "non-passing sight distance" or "passing sight distance" must be worked out carefully for each location and route.

The importance of grades with respect to the operating cost of trucks and busses is obvious. But the effect upon their running time may in some cases have even greater economic value.

Principle 62

ALL FOUR-LANE HIGHWAYS SHOULD BE DIVIDED. Head-on Collisions, Sideswipes, and Rear-End Collisions Resulting from Unsuccessful Attempts to Pass Must Be Made Impossible.

The value of raised medial strips or dividers is evident. As the potential speed of automobiles and highway surfaces has increased, the average motorist has traveled at a higher average speed. This has brought more overtaking of slower cars, which often requires driving to the left of the center line in the face of oncoming traffic. This practice has resulted in many

Courtesy California Highway Department.

Raised arrows discourage use of fifth lane.

head-on collisions between cars in the high-speed lanes of traffic. Headlights have not been improved sufficiently, nor used by the operator in a sufficiently safe manner, to remove all glare to the oncoming driver. Some motorists still insist on turning around on the highway between intersections. Others, wishing to make left turns, have no protected area in which to wait and are frequently struck by through traffic. Main trunk lines are still endangered

and delayed by too frequent crossroads. As traffic volumes and speeds increase, the foregoing difficulties will increase.

A solution for these problems is the raised medial strip of parkway on four- and six-lane highways. It is a means of making head-on collisions physically impossible, and it can be designed to afford protection for left-hand turns at intersections. It reduces headlight glare, makes U turnings impossible, and can be used to reduce the number of intersections crossing trunk lines. It may also be utilized for storing disabled vehicles.

Bryant Burkhard.

Raised medial divider continues through underpass.

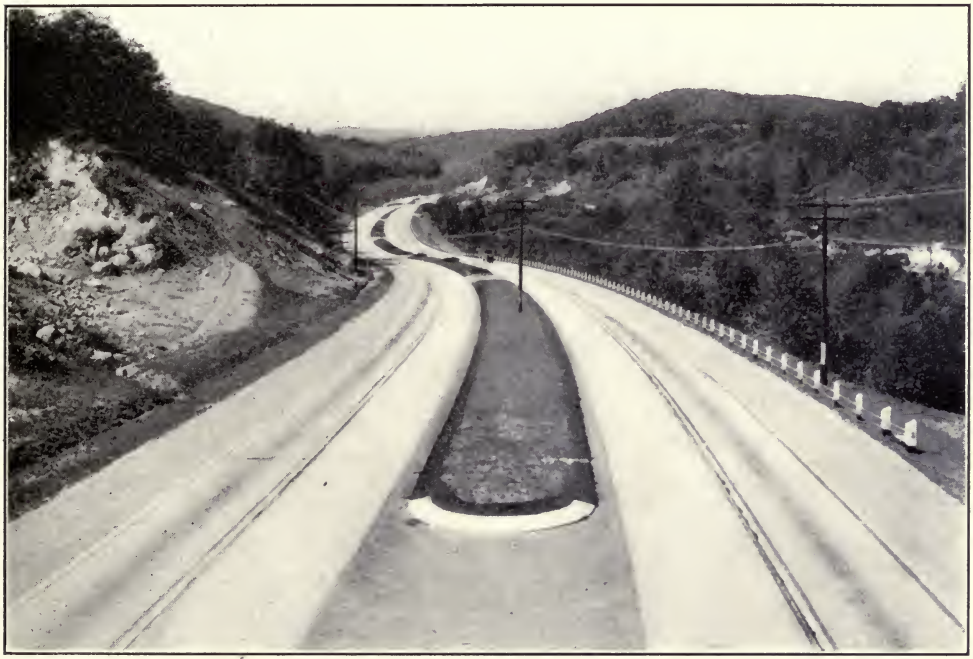
The shoulder of the roadway next to the outside lane should be so improved that motorists will drive close to it. Similarly, the inside lanes should be wider than 10 feet, or, if concrete is used, a strip of less expensive material, a foot or two wide, should be placed between the inside lane and the curb of the raised center strip. If this is not done, motorists will tend to shy away from the curb and will not use the center of the lane. The curbs may well be of the parkway or slanting type, so that in case of emergency a vehicle may climb the raised strip to avoid accident.

The width of the center strip should be determined by the amount of

space available, in units of 10- to 13-foot lanes for future expansion. It should probably not be less than 3 feet at any point.

Artistically the center strip has many advantages and can be planted with grass or low shrubbery.

If the center strip is to serve as a protection for left turns from the main highway, where the turn cannot be prohibited or a grade separation provided, the strip should not be less than 15 feet wide. If the divider is to be used as an elongated rotor to prevent the direct crossing of unimportant



Courtesy New Jersey Highway Department.

Mountable edges permit "elbow room" in emergencies.

roads, it should be 30 feet, for otherwise cars could not turn around it without swinging into the outside lanes.

Where gaps are made between intersections to permit change of direction, the center strip should be wide enough to provide a protected area for the turning movement, and the curve should be of such radius as to release the turning vehicle in nearly the same direction as that of the traffic stream which it enters.

On grade crossings the center strip should be widened to at least 30 feet at intersections, to take care of left turns.

Stage construction of divided highways is desirable. In laying out a

trunk-line highway the lanes on the outside should be built first, so that the property that may develop along the borders will not have to move back at a later widening. The center strip would then start out about 50 feet in width, with two lanes on each side. Later it might be reduced to 25 feet, and two lanes added on the inside. The controlling factor would be the final width needed to protect left turns.

Courtesy New Jersey Highway Department.

Reflecting curbing and permanent white center lines represent modern design.

Three arguments have been advanced against the raised medial strip:

First, that it is costly. However, the additional expense is comparatively small. And it should be remembered that, as a matter of fact, in many instances the increased width should be acquired anyway, in order to provide for future expansion. In making cuts through or around the side of hills there is no reason why the two roadways should be kept together. They can be separated and the most advantageous line and grade chosen for each one.

Second, that the entire roadway space is needed for the flow of traffic. This is refuted by the fact that two or three lanes in each direction will probably take care of the traffic demands; the real limitation on capacity is the intersection at grade, not the width of the highway.

Courtesy New Jersey Highway Department.

Where curbings are needed for delineation their effectiveness can be increased by reflecting panels and the color of the materials.

Third, that if an unbalanced flow were desired, one lane in one direction and three in the other, the raised center strip would be a hindrance. This contingency may arise near large metropolitan areas, but this type of flow is exceedingly difficult to accomplish without constant police patrol, and it has seldom been successfully applied.

Principle 63

PROVISION MUST BE MADE FOR OVERTAKING AND PASSING BY WIDENING OR PROVIDING ADEQUATE SIGHT DISTANCE AT INTERVALS. Differences in the Power of Vehicles or in the Speed Each Motorist Desires Will Always Present an Overtaking and Passing Requirement.

Provision for overtaking and passing may be made by adequate sight distance or increased number of lanes. It must be remembered, however, that successful passing depends also upon the frequency of oncoming traf-

Courtesy New Jersey Highway Department.

Reflecting panels show up under headlights at night to delineate medial divider.

fic, and hence that as traffic volume increases sight distance alone will not make passing possible.

The use of three lanes of the dual highway type will naturally increase the opportunities for passing, particularly in localities where an unbalanced flow exists, namely, where the bulk of traffic goes into town in the

morning, thus creating a demand for most of the passing in one direction, and out of town in the evening, again creating a demand for passing mostly in one direction. Since three-lane highways encourage the motorist to pass, they should not be used on curves or hills. Furthermore, it seems highly desirable to make the middle lane less attractive for general cruising than the outside lanes by providing for it a rougher surface and darker color.

Courtesy New Jersey Highway Department.

Some reflecting panels in curbings are highly effective in the rain when delineation of the medial divider is very important.

The four-lane divided roadway is the only type that will guarantee the safe passing of vehicles under normal conditions. Delay studies will often indicate that the expense of adding two lanes to the two-lane highway, or one lane to the three-lane highway, is warranted.

There are numerous possibilities of fitting the roadway to the landscape on curves and hills, thus providing increased esthetic advantages as well as reducing the cost of widening.

The frequency of passing zones is significant. There is a limit to the patience of the motorist; if safe passing zones are not provided at sufficiently frequent intervals, he will attempt to pass under unsafe conditions.

The severity of the no-passing irritation to the motorist, in terms of reduced velocity, must also be considered. The presence of exceedingly

Dave Packwood.

The guard rail moves to the middle of the highway.

slow trucks on a roadway creates even more impatience than slow-moving passenger cars, and highways much used by trucks must receive serious consideration.

It is possible to establish a reasonable measure of the motorist's patience in terms of the frequency and severity of delay where passing is not made safe. Each state should establish a standard, so that it may say to its motorists that provision for safe passing has been made at specified distances.

In attacking the overtaking and passing problem it is suggested that improvements be undertaken in the following order:

1. Increase the sight distance. This will probably hold until increased volume destroys its utility.

2. Widen at critical points, such as hills on straightaways at "patience limits."

3. Widen to three lanes on straightaways as a satisfactory solution until outmoded by increased volume.

4. Widen to four lanes at curves and hills. All widening must be done gradually enough for the prevailing speed.

Courtesy Oregon Highway Department.

Color contrast aids medial divider.

No highway system can hope to be successful unless the function of overtaking and passing has been provided for in terms of frequency and importance.

The passing situation could be made much less difficult by reducing the demand for passing on the highway and by enacting minimum speed laws. Either would require considerable educational and enforcement effort before it would be successful.

CHAPTER XVII

LANES

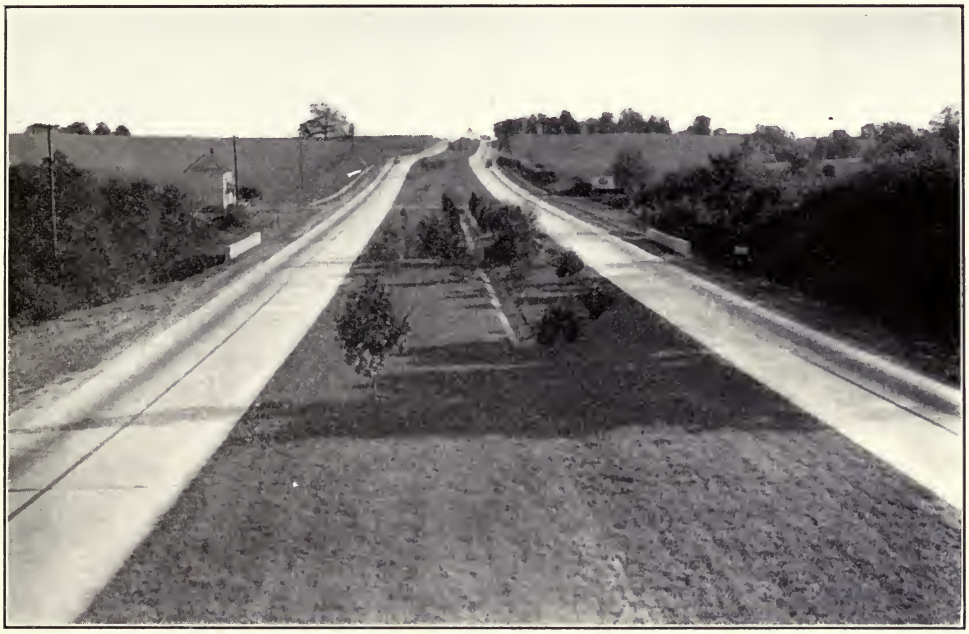
This chapter considers three important elements of the lane, the basic unit of the highway upon which its logical expansion is dependent. As speeds have increased, the width of the lane has increasingly become a

Courtesy Canadian Highways.

Low curbing delineates the center strip.

function of velocity. Since original construction cannot easily be altered at a later date, lane width is of pressing importance. The efficiency of lanes can be increased by making outside lanes appear and actually be safe, thus encouraging their use rather than frightening motorists away, and by making them more attractive by width, surface, and color. Even

in cities, where velocities are lower, cramped lanes will be found to have a constricting effect which will either cause accidents or increase congestion by forcing motorists to slow down to avoid hazards.



Courtesy Delaware Highway Department.

Low planting reduces headlight glare.

THE DESIRABLE WIDTH OF HIGHWAY LANES IS JUST AS MUCH A FUNCTION OF VELOCITY AS OF VEHICLE WIDTHS. As Speeds Increase, the Tolerance or Factor of Safety Must Be Increased.

The automobile started out in America with a fairly wide wheel span and body. Many states permit a maximum vehicle width of about 8 feet.

Courtesy Michigan Highway Department.

Michigan Highway Department has built 300 feet of medial barrier designed by Yale Traffic Bureau.

With a 10-foot lane, this leaves only 12 inches of clearance on each side, or a total of 2 feet between vehicles of maximum width. At low speeds the amount of clearance was not so important as it is at the higher average speeds of today. Strong cross-winds coming in puffs may require as much as 2 or 3 feet of lateral space for steering recovery.

On curves the lanes should be widened, the additional width depending

upon the sharpness of the curve. Many curves have 12- to 14-foot lanes. Certainly, in all new construction, no lane should be less than 10 and no roadway less than 20 feet wide. Widths less than this are sure to invite accidents, yet 14-, 16-, and 18-foot two-lane pavements are still built in some localities.

Where speeds of 40 to 60 miles per hour or more are anticipated, lane widths should be increased to 12 or more feet, and such lanes must be clearly marked, even by using differently colored pavement surfaces for adjacent lanes. On two-lane, two-way highways, from 1 to 2 feet of each lane nearest the center line is lost because cars approaching each other at

Courtesy Michigan Highway Department.

Car comes off barrier safely at 60 miles per hour.

high speed will not drive close together. Unless adequate flat shoulders are provided, a similar space on the outside will be lost. This increased width of 2 to 4 feet over the old standard 10-foot lane is especially necessary where puffy cross-winds prevail. Under these conditions, it is probable that the average driver cannot hold his car within 3 feet of lateral movement. But the inside lanes must have adequate widths for high-speed passing maneuvers.

In some places it may be advantageous to make the two outside lanes of a four-lane highway wider than the innermost ones in order to encourage

all vehicles to use the far right lane except when passing. Since a wider lane is always more attractive, this inducement has a real appeal.

Additional lane width may also increase capacity by relieving the cramped feeling that narrow lanes give the motorist.

A correct decision as to a lane width that will hold adequate for many years is important. If concrete is used, the joints form a permanent lane

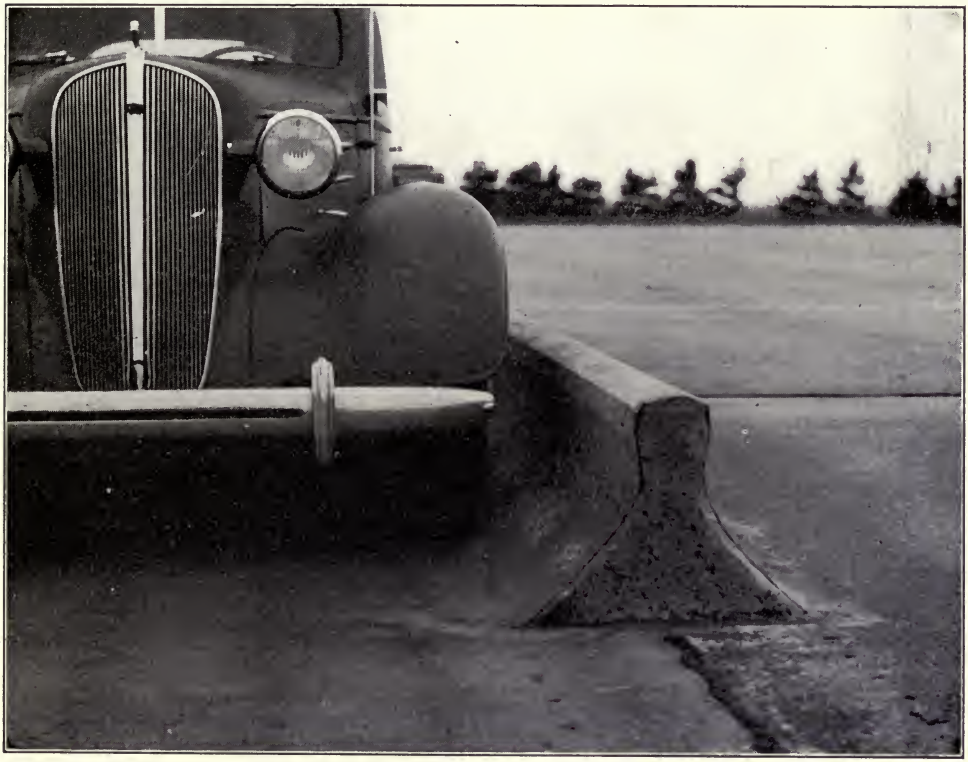
Courtesy Long Island Park Commission.

Careful design may not require much room to prevent head-on collisions.

line. If the lane is later widened, the old joints will serve to confuse the motorist.

The effective operating width of a lane must really be measured from points on the edges where any fixed obstruction, drop-off, or other hazard exists. A lane may be 10 feet wide, but if there is a 6-inch vertical curb along one edge of it, a considerable number (depending upon the speed) of feet of pavement surface will be wasted because motorists will not drive close to a fixed object which may constitute a hazard.

Lanes in excess of 13 feet may cause some difficulty at low speeds by drivers attempting to squeeze three lanes of moving traffic into 26 feet of pavement surface, especially where traffic is stopped at intersections or railroad grade crossings. Under some conditions this is undesirable.



Courtesy Long Island Park Commission.

Concrete adaptation of medial divider has possibilities.

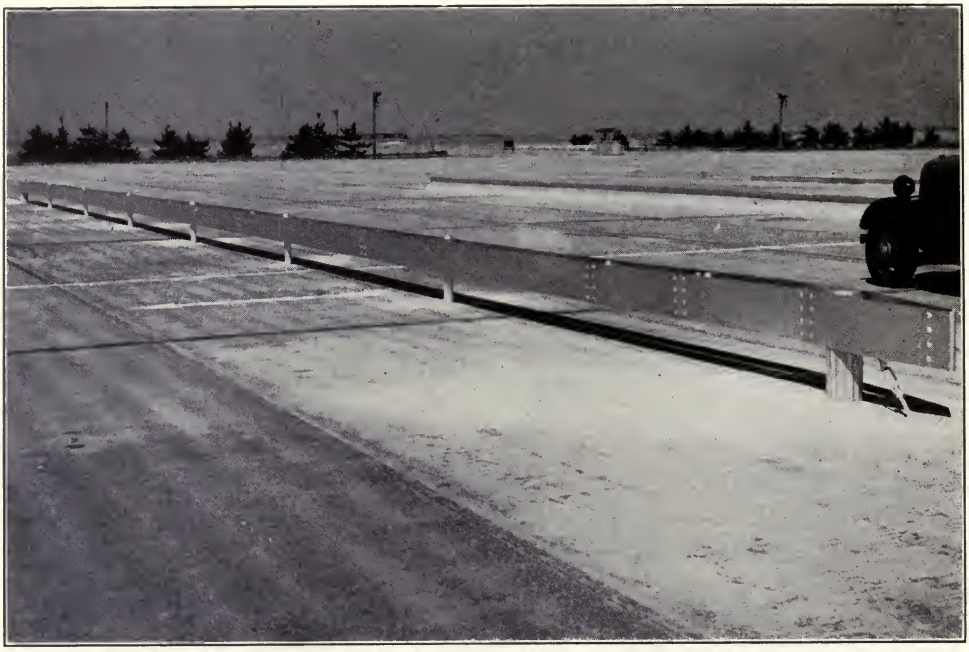
Where three lanes of movement are required in large metropolitan areas, as on Long Island, New York, mixed lane widths may be provided, as one 11-, one 12-, and one 13-foot lane.

Courtesy Long Island Park Commission.

Even low curbings may be superior to paint lines for lane control.

Courtesy Long Island Park Commission.

Reflecting panels on top of dividers may prove feasible.



Courtesy Long Island Park Commission.

Smoother guard rail may have possibilities for dividing roadways.

Courtesy Long Island Park Commission.

Highway proving ground tests narrow dividers for cramped roadways.

Courtesy Long Island Park Commission.

The guard rail undergoes tests as medial divider.

Courtesy Long Island Park Commission.

Parabolic medial divider installed on old four-lane undivided roadway, without widening roadway.

Principle 65

TRAFFIC SHOULD BE ATTRACTED TO THE PROPER LANE BY DIFFERENCES OF PAVEMENT SURFACE, SMOOTHNESS, AND COLOR; BY WIDTH OF LANE; AND BY MARKINGS. Automatic Compliance by the Operator Will Be Found More Effective than Educational or Enforced Compliance.

The principle of attracting traffic to where it should go is thoroughly sound; it has been proved in practice and it should be applied much more

Courtesy Missouri Highway Department.

Difference in pavement color helps keep drivers to right, but they still do not like nearness of trees and telephone poles.

extensively in the future. It is a vastly less expensive method of reducing accidents and congestion than education or enforcement.

Unfortunately, motorists long ago formed the habit of driving in the middle of the road. The chief reasons for this were (1) high crowns, which tended to make steering on the outside difficult, (2) guard rails too close

to the traveled portion of the road, and (3) parked cars that had to be avoided. Besides these, the visibility was often better from the middle, which made some drivers feel safer, and last, but not least, the surface was usually better in the center. This last reason illustrates an important principle of traffic control: motorists always seek the smoothest surface.

It is obvious that any lanes above two are valueless unless the slow traffic can be kept to the outside in order to leave the center lane or lanes

Bryant Burkhard.

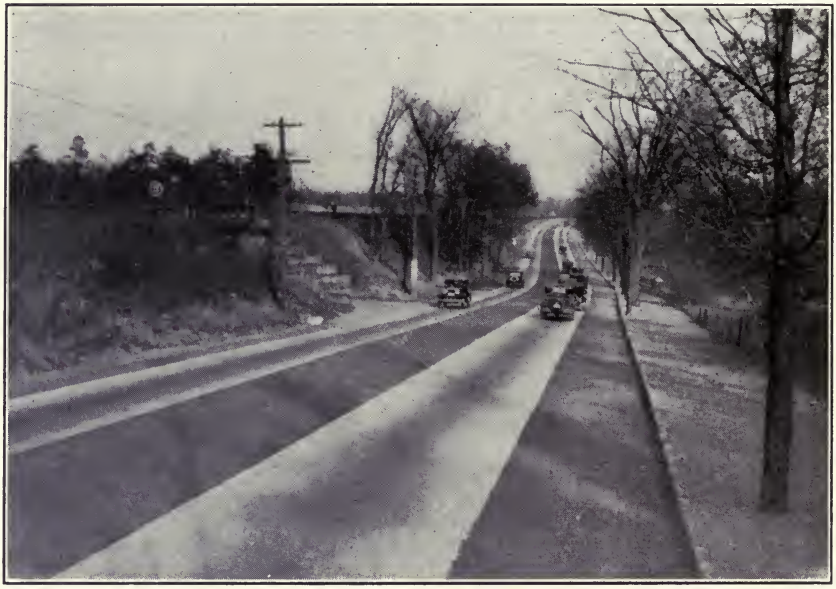
It is easier to follow a lane of a distinctive color than to drive between paint lines.

available for passing and for the high-speed vehicles. On the average 30-foot, three-lane concrete or macadam highway there is a tendency to drive just off the center, thus straddling the lane lines and making it impossible for anyone to pass in either direction. On four-lane highways there is also a tendency to drive on the inside lanes, thus necessitating passing on the right, a practice especially dangerous at high speeds.

The usual method of keeping slow-moving vehicles to the right is to paint lane lines and have motorcycle officers enforce observance of them. However, this is an expensive procedure, and it would be almost impos-

sible to obtain enough officers to patrol all the multi-lane highways. The same result can be accomplished to a considerable extent without officers by making it easier and more comfortable for the motorist to do the right thing. Much can be done through design, as Massachusetts and several other states have demonstrated through the use of dual-type highways.

Dual-type highways are those having a distinction in color and in the smoothness of the surface between the inside and the outside lanes. Massachusetts has some excellent examples of the three-lane and four-lane high-



Maxwell Halsey.

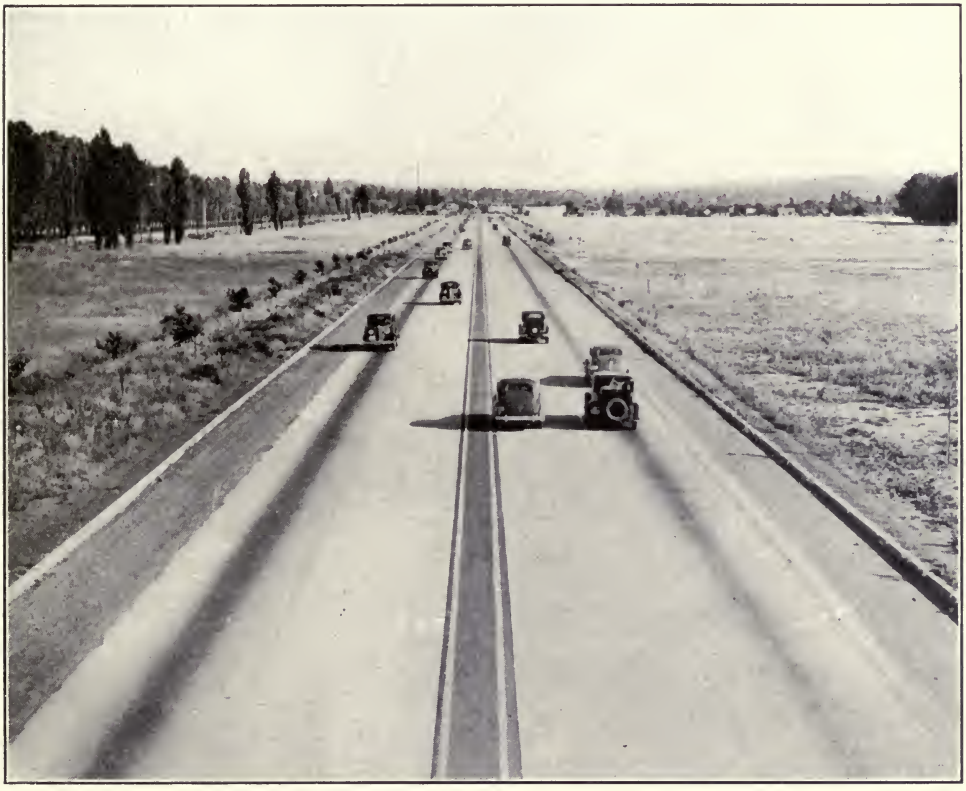
Motorists prefer to stay on correct lanes when outside lanes are smoother and lighter.

ways of this type. The center lane or lanes are usually constructed of a dark rough macadam which causes the tires to rumble slightly; the outside lanes are of smooth cement, light in color. The difference in smoothness and in color makes the motorist prefer to drive on the concrete, leaving the center macadam lane or lanes free for passing and for higher-speed vehicles.

Unless the slow-moving vehicles are kept to the right, a three-lane highway is likely to carry no more traffic than a two-lane ordinary highway. As long as the outside lanes have a smoother surface and lighter color, it does not matter what material is used.

Dual-type highways have certain limitations. The three-lane dual-type highway is unsuitable on hills or curves where visibility is curtailed, as it tends to encourage passing where it is dangerous. The four-lane

dual-type divided highway might be inadvisable near large metropolitan areas where a strong unbalanced flow exists; but, as a matter of fact, the author has never seen a four-lane highway which has carried three lanes in one direction and one in the other successfully without constant patrol and rigid enforcement at a prohibitive expense. Some engineers argue that difficulty would be encountered in joining the concrete and macadam, although so far this apparently has not been found true in Massachusetts.



Courtesy Oregon Highway Department.

Oil pattern proves value of adequate shoulders in making outside lanes more popular.

In the past the reputation of the dual-type highway has been jeopardized by poor design. In some highways the center lane was only four or five feet wide. In others the cement was too smooth and slippery, and motorists drove with one wheel on the macadam to prevent skidding, thus destroying the utility of the center lane for carrying traffic. Often the shoulders were not sufficiently attractive for parking, and motorists drove near

the center to avoid parked cars and pedestrians where no sidewalks had been provided. In still others guard rails and other fixed objects were too close to the outside lane to permit use of the highway at high speed.

Color differentiation may also mark accelerating and decelerating lanes and, sometimes, the path of a particular route, although this last possibility might cause confusion or be subject to change.

Principle 66

OUTSIDE LANES MUST BE MADE USABLE. Shoulders Must Be Provided, Trees and Telephone Poles Removed, and Access Controlled if Motorists Are to Be Induced to Use Outside Lanes.

Obstructions should be pushed back far enough from the roadway so that if a motorist is forced off the roadway he will have sufficient space in which to slow down and stop.

Multi-lane highways are not effective unless the outside lanes carry their share of the traffic. Unless these lanes are made thoroughly usable,

Courtesy Kansas City Traffic Engineering Department.

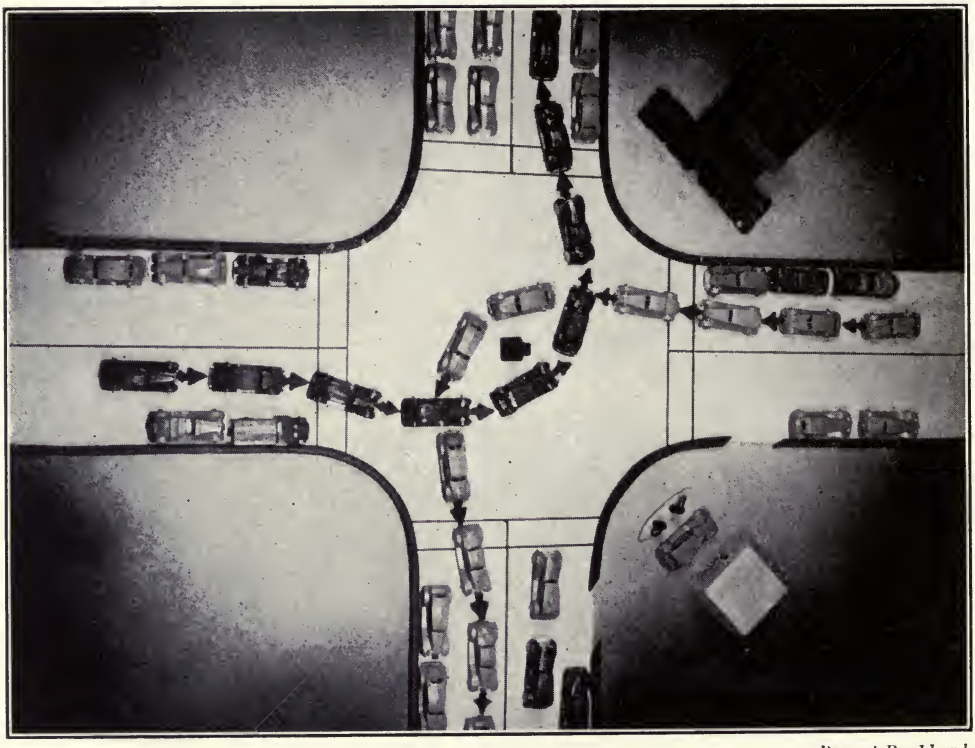
Lanes are not efficient if poor shoulder and bad ditch keep drivers too near the middle of the road.

the motorist cannot be made to use them. An important principle in traffic control, as already mentioned, is that at high speed the motorist will not pass close to fixed objects but will swerve away from them. If the guard rails, such as at culverts, are too close to the outside lane, the motorist will move over and straddle the two lanes.

Incidentally, guard rails have been used to advantage to define no-stopping areas in front of filling stations, refreshment stands, and other places which are likely to encourage troublesome and dangerous parking. If definite points of entrance and exit are established, the motorist will

know where to look for interference, and the area of danger will be reduced. Furthermore, guard rails placed close to the edge of the pavement positively identify the spaces where no parking is permitted.

Unless the shoulder is made attractive, motorists will not park on it but will park with at least one wheel on the traveled portion of the highway. This causes one swerve after another, which obstructs visibility,



Bryant Burkhard.

Some state laws require this awkward movement, thereby doubling left-turn conflicts.

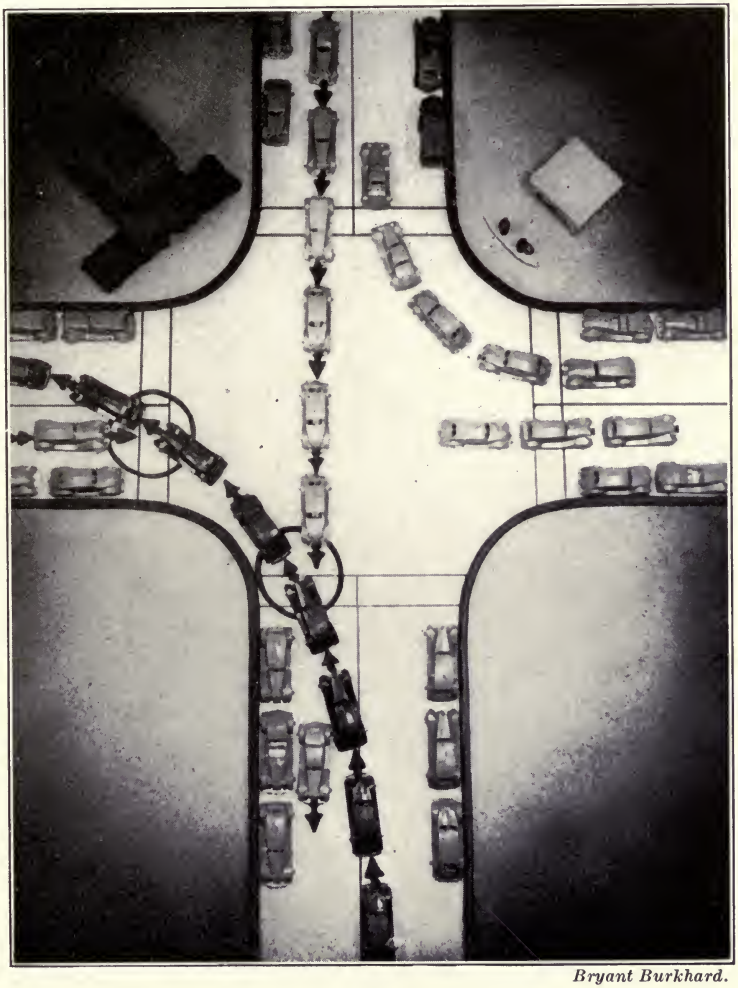
causes accidents, and reduces the effectiveness of the lane. Pedestrians hesitate to walk on the shoulder unless its surface is almost as hard and smooth as that of the traveled portion of the roadway.

The protection of outside lanes may have a bearing on the capacity of the roadway. If the motorist is constantly worried about the edge of the road, his anxiety will be reflected in reduced speed.

CHAPTER XVIII

INTERSECTIONS

The principles in this chapter deal with the most critical element of geometric design. Very often the intersection will control the time-saving



Bryant Burkhard.

When cars cut corners, two confusion areas result.

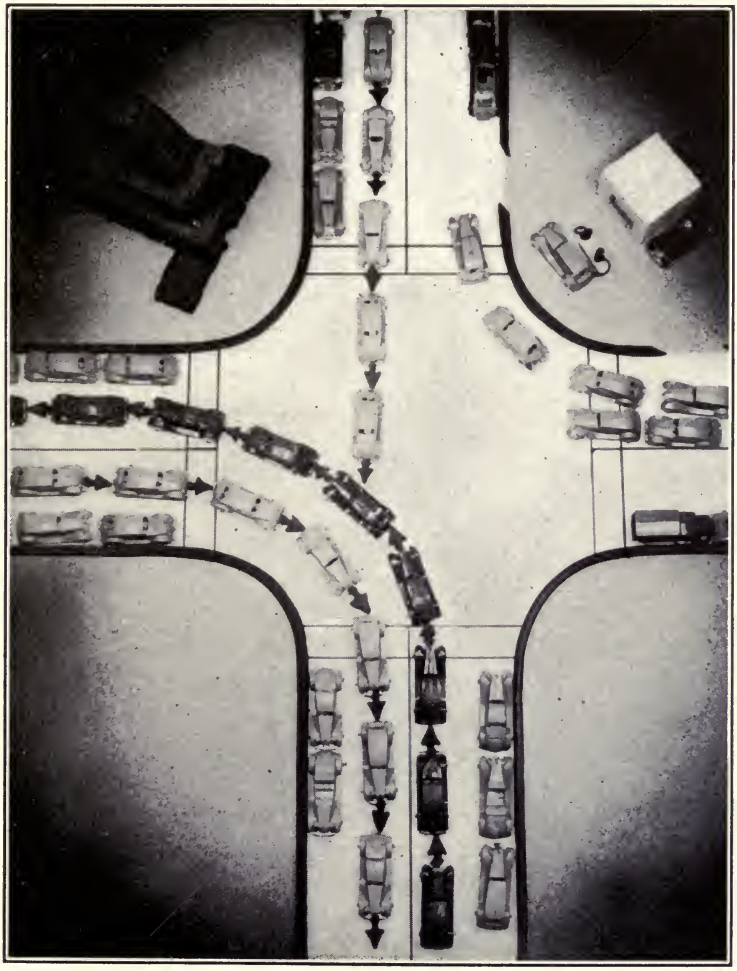
service of a route as well as its accident rate. It is more costly than most parts of a route. Fourteen basic elements of intersections have been se-

lected for treatment: (1) The importance of capacity. (2) The disadvantages of different types of intersections. (3) The relationship between the natural path of vehicles and design. (4) The losses of multiple intersections. (5) The necessity for reducing the number of conflicting movements. (6) The checking of problem intersections. (7) The controlling factors of the angles of convergence, divergence, and intersection. (8) The channelization of large open areas. (9) The control of the individual movement. (10) The reduction of roadway widths by funneling or condensing lanes. (11) The control of paths of turning movements by throat lanes which reduce speed to the desired level and release the vehicle in the desired direction. (12) Accelerating and decelerating lanes. (13) Rotary traffic circles. (14) Grade separations.

PRINCIPLE 67

THE INTERSECTION AND NOT THE WIDTH OF THE HIGHWAY DETERMINES THE CAPACITY OF THE SYSTEM. The Intersection Has an Unchangeable Constant Basic Inefficiency of Approximately 75 Per Cent under Capacity Operation.

The total width of the highway must be determined by (among other factors) the amount of traffic and the necessity for passing. It would be



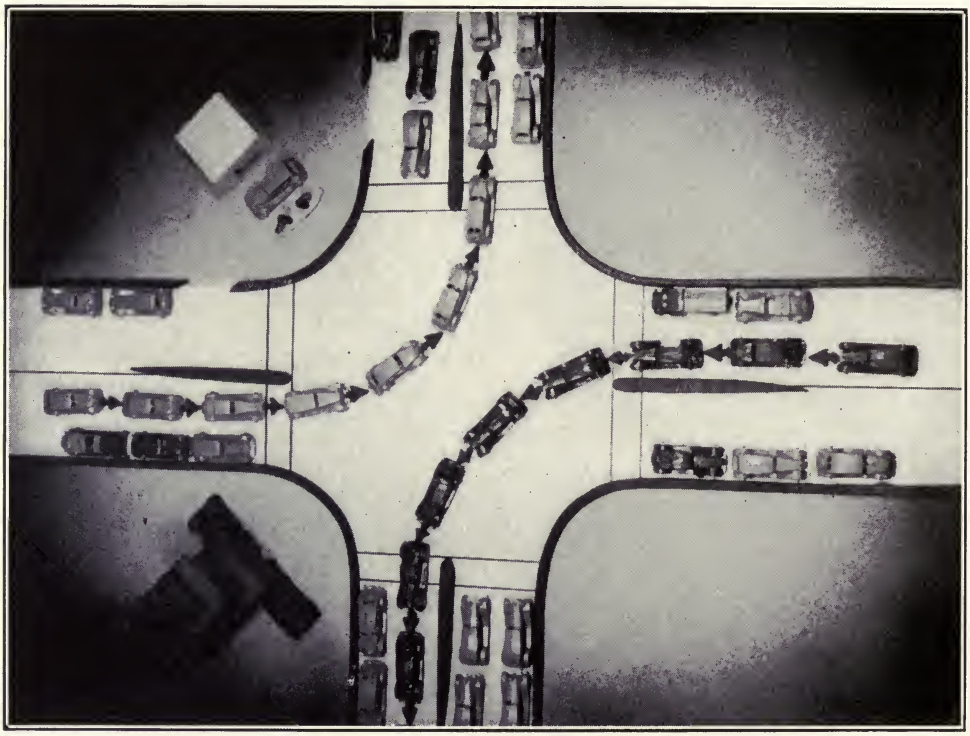
Bryant Burkhard.

Correct left-turn provides easier movement.

unwise to build nothing but 20-foot roadways, and then to build parallel roads as they become congested. Yet some jurisdictions are suggesting

this. The highway must make provision for two separate classes of vehicles: the slow-moving and the faster vehicles. On a two-lane road, long before its actual capacity is reached, the passing problem will have restricted the speed of vehicles to that of the slowest unit.

Accidents will be caused by motorists who, impatient of waiting, pull out of line and take abnormal chances in passing without having sufficient



Bryant Burkhard.

Channelizing islands physically enforce correct left turn.

sight distance. Whenever traffic becomes fairly heavy upon a two-lane road, passing becomes hazardous, impracticable, and soon impossible, and the road should be widened. The three-lane road makes provision for passing, and if the flow is usually unbalanced in one direction or the other, it adds materially to the capacity of the roadway and to the convenience of travel. The problem of keeping the slow-moving vehicles in the outside lanes can be solved and has been discussed. The limitation on the three-lane road comes at curves and hills, where passing in both directions is dangerous because of poor visibility, and at the time when volume increases so that there is a continuous demand for passing in both directions.

The four-lane highway (with all limited-way functions provided) makes complete provision for passing and at an estimate of 2000 vehicles per hour per lane will handle 8000 vehicles per hour in both directions, or 4000 in one direction if traffic moves continuously. Numerous traffic

Bryant Burkhard.

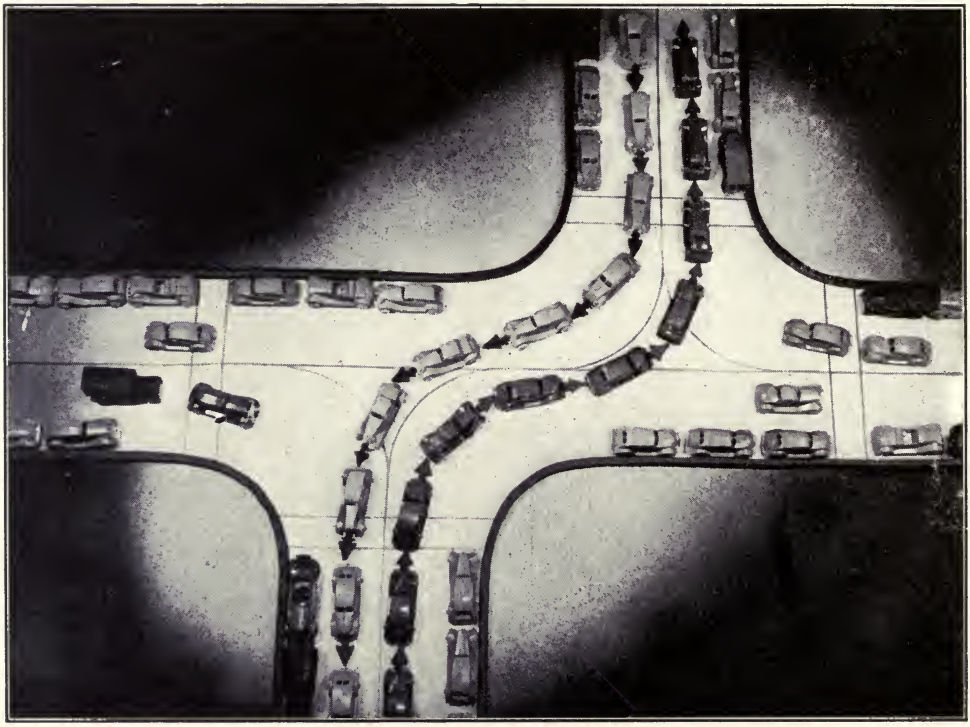
"Y" intersections provide head-on collision angle, large area for open-field running, and long clearance distance.

counts have shown that this capacity will suffice for most flows except those within or immediately adjacent to large metropolitan areas. Greater capacities can be obtained with four-lane highways and grade separations at heavy crossing points than with six-lane and eight-lane highways with-

out grade separations at important crossings. If the cross flows were as heavy as the main flows, this situation would result:

4 lanes uninterrupted at 2000	8000 vehicles per hour
6 lanes interrupted (25% of 2000)	3000 vehicles per hour
8 lanes interrupted (25% of 2000)	4000 vehicles per hour

Under equal flows the intersection can carry only about 25% of the flow which enters it. Even if flows are not equal, the rate will be about the same wherever all blocks are filled and the approaching flow per minute exceeds the capacity of the intersection. Only one street or highway can move at one time,



Bryant Burkhard.

Offset intersections provide "S" curves and constant interference with pedestrians.

and this reduces the capacity to 50 per cent. It has been estimated that another 25 per cent is lost through stopping and starting vehicles, even with efficient traffic signals.

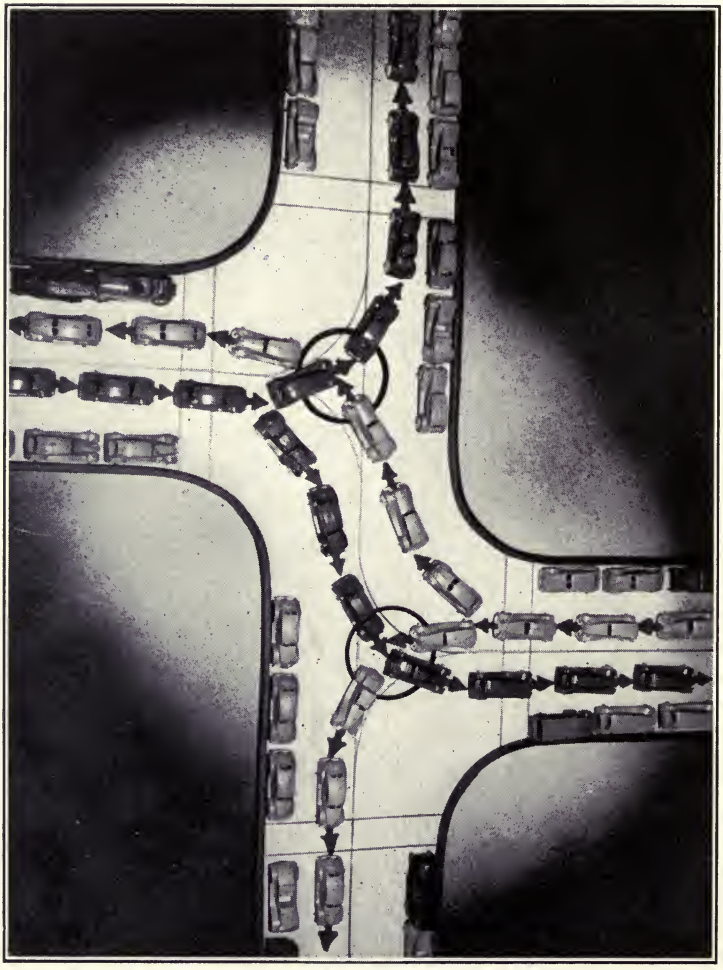
Since the efficiency per lane decreases as the number of lanes increases, because motorists weave constantly from one lane to another, there is some doubt as to the advisability of building highways wider than four lanes, except in or near large metropolitan areas. However, where three general

classes of vehicles—slow commercial unit, faster commercial unit, and still faster passenger car—use the same facility, there would be a demand for two separate passing movements in each direction, which the four-lane highway could not satisfy and which would require six lanes. Beyond six lanes, however, with an estimated uninterrupted capacity of 12,000 vehicles per hour, parallel and supplementary roads might prove more efficient than additional lanes. "Weaving" increases with the number of lanes and reduces the estimated capacity while increasing the hazard of each lane.

Principle 68

AT GRADE, RIGHT-ANGLE, TWO-CROSSING STREET INTERSECTIONS ARE MORE SATISFACTORY THAN SKEWED, OFFSET, "T," OR "Y" INTERSECTIONS. Thus Whenever Possible Efforts Should Be Made to Change All Intersections to a Customary Right-Angle Type if Two-Way Movement Is to Be Permitted on Each Entering Street.

Irregular intersections produce a greater variety of conflicting movements, more overlapping conflicts, greater confusion areas, greater length of crossing, more "lock-ups" from left turns, more unsatisfactory angles,



Bryant Burkhard.

Signal timing is difficult at offset intersections.

more pedestrian hazards, and greater congestion losses from signal clearance and special periods than those produced by right-angle intersections.

Large open intersections, including the increased area produced by the "Y" or skewed intersection, produce a great many common faults. They increase the length of crossing time of vehicles and pedestrians. This increases the hazard to the pedestrian as well as the inefficiency of the change period where traffic signals are used. Large areas multiply a potential conflicting movement to many points of conflict. They increase the possible choice of routes, thus encouraging violations and making it increasingly difficult for one motorist to guess the path of another. Not infrequently the open area creates an optical illusion of "plenty of room" and thus encourages fast driving. In addition, the open area permits cheating on the part of some motorists, thus creating double or triple lane movements which must inefficiently be forced down to a single lane on the far side of the intersection. Such "chiseling" creates a weaving problem which reduces the capacity of the one lane below that which would be obtained if only one lane were flowing.

In addition to the open-area difficulties it contributes, the Y intersection introduces angles of movement that are almost head-on in character. The Y also forces the motorist to look over his shoulder at an awkward angle to see whether a car is coming on the other leg of the Y. Both Y and T intersections are particularly hard on pedestrians where traffic signals are used because traffic is constantly crossing the path of the pedestrian, no matter which way he tries to cross.

The offset intersection doubles the left-turn conflicts, creates bad angles of vision, and forces the motorist to depart from his normal path. Where signals are used, it gives continuous movement, thus blocking the pedestrian.

Of course, the difficulties produced by different types of intersections vary a great deal, depending upon whether the area is urban or rural and whether pedestrians are present.

In general, nevertheless, every effort should be made to build standard right-angle intersections and to standardize those which do not follow that pattern.

Principle 69

TRAFFIC DESIGN SHOULD BE MOLDED TO FIT THE NATURAL PATH OF THE MOTORIST. Under Normal Circumstances the Majority of Motorists Will Select What May Be Described as a "Natural Path."

The natural paths of motorists are clearly indicated by oil droppings and snow, dust, and headlight patterns. The fact that for similar types of movements these various patterns are not very wide indicates quite clearly the consistency of the majority of drivers in steering their automobiles.

Courtesy New Jersey Highway Department.

Natural path of downhill vehicles cuts the corner and does not follow path suggested by design.

It is quite probable that definite natural paths exist for different conditions. Thus far little has been done to measure these paths or to determine the effect of design upon them.

Design should not be arbitrary or assume that motorists will follow whatever artificial channels are created; it should fit the natural paths. If this is not done, design will require exceedingly strong physical barriers to

force the motorist away from his normal path. The more closely design fits the natural path, the less need there will be for curbings or physical barriers; all that will be required under most circumstances will be delineation.

Since it is necessary to change the "natural" paths of motor vehicles

Bryant Burkhard.

The "Y" intersection needs special treatment to remove its one bad intersecting angle.

for purposes of intersection, convergence, and divergence, the change should be accomplished by utilizing those elements of design which help or stimulate the motorist to change his direction. If care is taken in the location and character of these stimuli, the motorist will be guided by his instinct and thinking in the desired direction. Such design, by being more

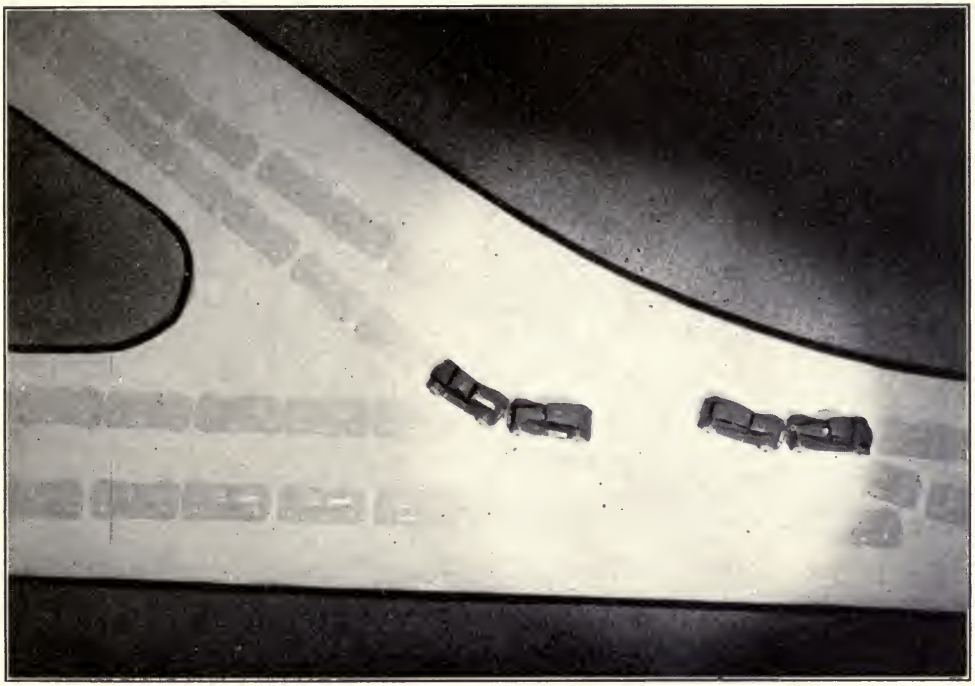
"natural" and less "artificial," would result in fewer accidents and delay and would be infinitely more pleasing to the motorist.

Additional research is strongly recommended on this subject. The measuring techniques mentioned above can provide a great deal of information upon present practice. However, additional research should be conducted to determine how the motorist would operate if he were not restricted by design as much as he is today. Unfortunately, it would for instance be difficult to provide different roadways with different superelevation to find the natural path under conditions where superelevation is used. These factors can be determined only by comparing the behavior of motorists on curves of equal radius and comparable conditions where different degrees of superelevation are used.

Principle 70

WHEREVER POSSIBLE, MULTIPLE INTERSECTIONS SHOULD BE REDUCED TO SIMPLE INTERSECTIONS. It Is Preferable to Simplify Complex Intersections with More Than Four Entering Streets, Making Some of the Minor Streets One-Way, away from the Intersection.

There is good evidence for believing that multiple intersections in general cannot be efficiently controlled by traffic devices. They are too near the driving limit of the average motorist to provide the necessary safety factors.



Bryant Burkhard.

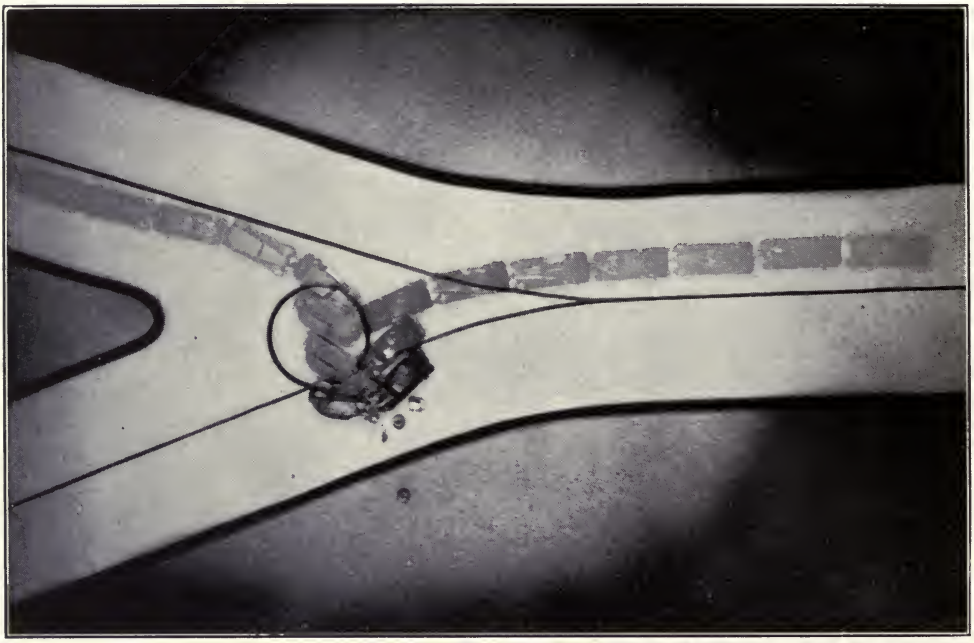
Two separate left turns show that operators get into trouble when given too much space in which to maneuver.

The chief objection to the multiple intersection is the greater number of conflicting movements which it creates.

Multiple intersections usually have a larger area of free space than simple intersections. This larger area multiplies each conflicting movement by the number of lane widths available in the open area. This produces considerable uncertainty as to whether the motorist may expect a conflict.

Multiple intersections also cause traffic signal losses, for, the area being

larger, the clearance period must be longer, and the number of clearance periods is increased. This may reduce the efficiency of the intersection to as low as 20 per cent. From the public-relations viewpoint, complex intersections irritate the motorist by making him wait a long time, often in the absence of cross traffic.



Bryant Burkhard.

If both cars can give way simultaneously, errors in judgment cause difficulty.

Wherever possible, complicated intersections should be reduced to simple intersections. Some of the methods of accomplishing this are:

1. Making some of the entering streets one-way away from the intersection.
2. Blocking off some entrances so that only right turns may be made.
3. Introducing traffic islands to create a smaller number of entrances.

Where an intersection of several roadways is considered, it may be advisable, if this number is greater than four, to create two separate intersections a block apart in the city and 1000 or more feet apart in the country. Two simple intersections would be likely to cause less exposure to conflict than a complicated one, primarily because the motorist would be confronted with but one simple problem at a time.

Principle 71

THE NUMBER OF CONFLICTING MOVEMENTS MUST BE REDUCED. The Paths of Vehicles Must Be Grooved or Channelized into a Small Number of Specific, Clearly Defined Crossings, so that the Motorist May Know Where Any Other Motorist Has a Chance to Cross His Path.

The reduction of conflicting movements is primarily a matter of reducing large open areas and of establishing definite channels.

Bryant Burkhard.

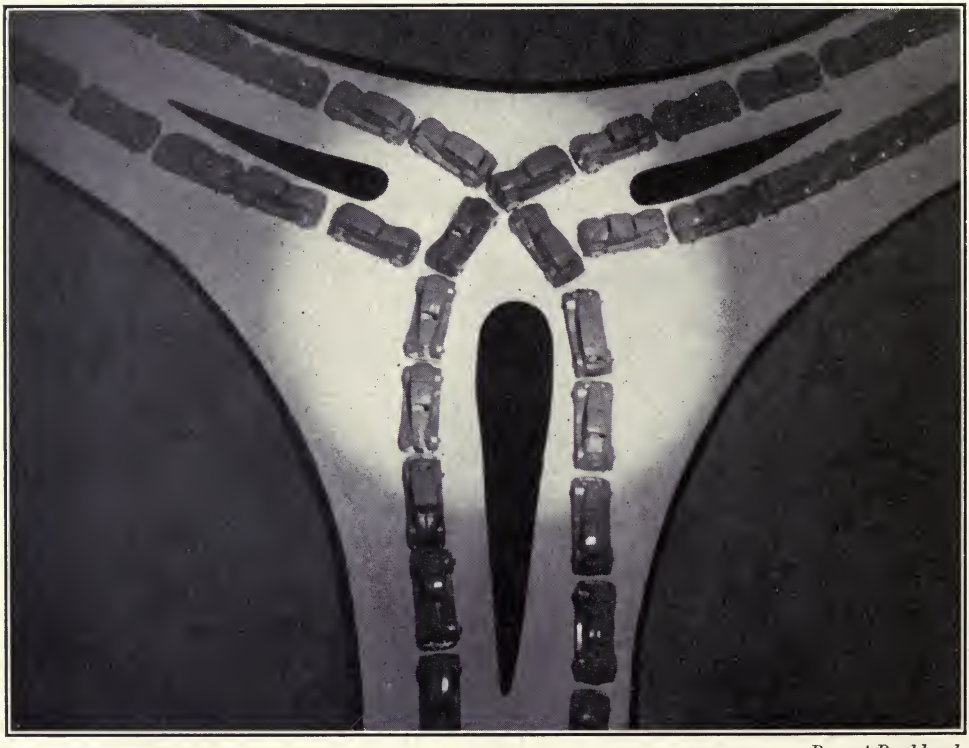
Three roads cause three bad head-on angles.

Disadvantage of Open Areas. The following are some of the complications which arise from large open areas:

1. They multiply the potential number of conflicts.
2. They encourage "open field running" by leaving to the operator the choice of a large number of maneuvers.
3. They produce a large number of different angles and different movements.
4. They are difficult to signalize.

5. They considerably increase the hazard to the pedestrian.
6. They are likely to create traffic jams.

Accidents and Exposure. It may be said that accidents are primarily the product of human error and exposure. The more opportunities there are for human error, the more accidents there will probably be. Exposure does not mean merely the traffic volume, but rather the volume of conflict-



Bryant Burkhard.

Channelizing islands change intersection angles from head-on to right-angle, and reduce speed.

ing movements. This volume includes the potential multiplication which results from increasing the area of the "conflict zone." The only successful method of reducing accidents in the face of the constant error inherent in human beings is by reducing the number of potential conflict exposures.

Controlled Situations Essential. In order to produce a situation which brings into play a minimum of human error, operating conditions must be controlled.

This means that the channel should be so arranged as to provide only one conflict of moving streams at a time. It is also important that there be adequate space between potential conflicts for the motorist to dispose of one problem and prepare himself to meet the next.

Principle 72

ALL PROBLEM INTERSECTIONS SHOULD BE CHECKED FOR THE CONFLICTING MOVEMENTS THAT MAY TAKE PLACE. This Will Show What Conflicts May Be Eliminated, What Angles of Merging, Diverging, or Intersecting Should Take Place, and What Confusion Area Exists. The Proposed Redesign Should Also Be Checked to Show the Number of Conflicts That Have Been Removed, and Which Angles Have Been Improved.

In many traffic situations it is more difficult to isolate the problem than it is to solve it once it has been isolated and defined. It is easy to

Bryant Burkhard.

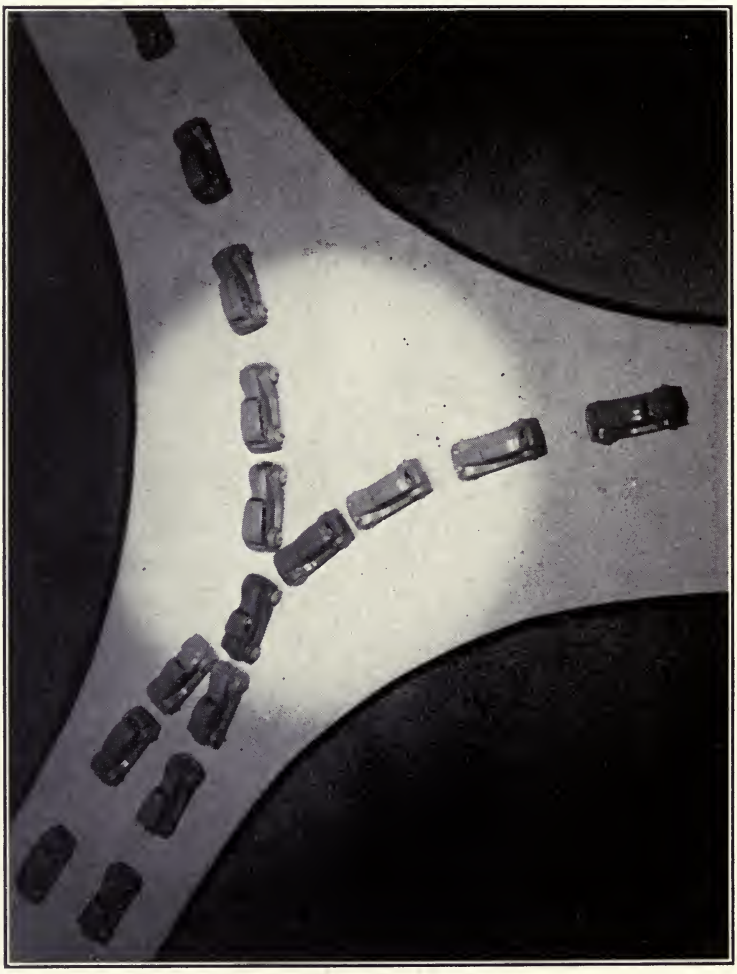
Even one turn has too much leeway and tempts drivers to cut the corner.

conclude that something is wrong with an intersection because it is the scene of numerous accidents and considerable congestion; but that contributes practically nothing to remedying the trouble.

Perhaps the most important analysis of an intersection where accidents

or congestion have been experienced would be to count the number of conflicting movements and study their distribution over the intersection area.

Once the number of these movements, the angles of intersection, convergence, and divergence, and the difference in speeds of approach have been determined, it would be possible to lay plans to improve operations.



Bryant Burkhard.

Two left turns are in conflict.

It is unlikely that any proposed remedy which does not make an advantageous change in the above movements would produce satisfactory results. Hence the proposed corrections should be carefully analyzed in these respects to make accurate comparisons possible.

With the comparisons of the existing and proposed plans well in mind,

attention should be given to the known elements of the behavior of traffic. These behavior items may well alter the changes in the flow which are anticipated because of new designs or controls.

This procedure would be fairly simple at individual intersections or isolated danger spots. However, when applied to proposed one-way street systems, for example, it might be found extremely complex.

If any proposed change in design or control plan completely eliminates any of the existing movements, a careful study must be made to determine how much inconvenience this will produce and how many conflicts will be transferred from the point at which the change is made to adjacent intersections or sections of the roadway. Unless this can be accurately determined in advance, it would be advisable to install temporary islands until the best basic pattern has been established.

THE ANGLES OF CONVERGENCE, DIVERGENCE, AND INTERSECTION ARE THE FINAL CONTROLLING FACTORS IN DESIGN. One of the Smallest Units of the Accident and Congestion Problem Is the Angle at Which Vehicles Approach Each Other. The Difference in These Angles Will Usually Decide the Potentials of an Accident or a Delay. Choice of Angles by the Operator Cannot Be Permitted because Human Urges, Weaknesses, and Errors Will Produce Dangerous Angles Which in Turn Will Eventually Produce Traffic Difficulty.

This phase of traffic movement has long been neglected. At the present time there do not exist factual research data to evaluate the relative merits

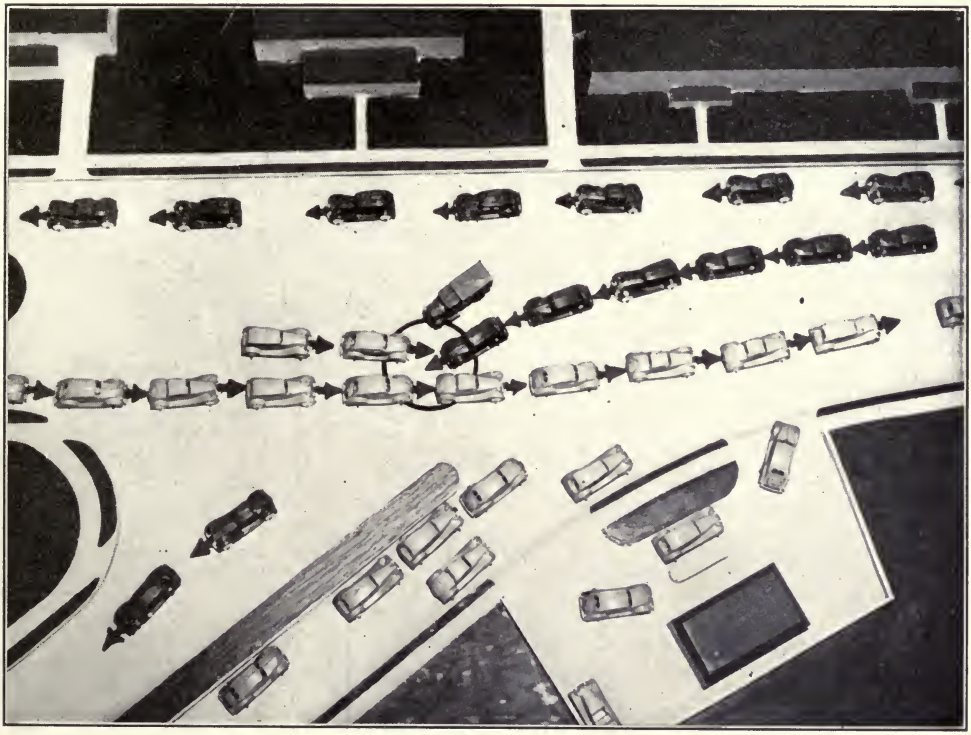
Bryant Burkhard.

Three conflict spots must be corrected.

and demerits of each angle. These data must be secured if perfect design is to be accomplished. Thought has been given in the past to the broad planning of thoroughfares, streets, highways, by-passes, etc. These comprehensive plans, however, cannot be expected to be successful unless their

component parts operate efficiently. These parts include intersections, curves, hills, and cross sections of the roadway. They, in turn, will not prove efficient unless the elements of their operation work successfully. The basic elements which control the relative effectiveness of any particular piece of roadway are believed to be closely associated with the angles of convergence, divergence, and intersection.

Most traffic technicians will agree that the most desirable angle of bringing together the paths of different traffic streams is an angle of less than



Bryant Burkhard.

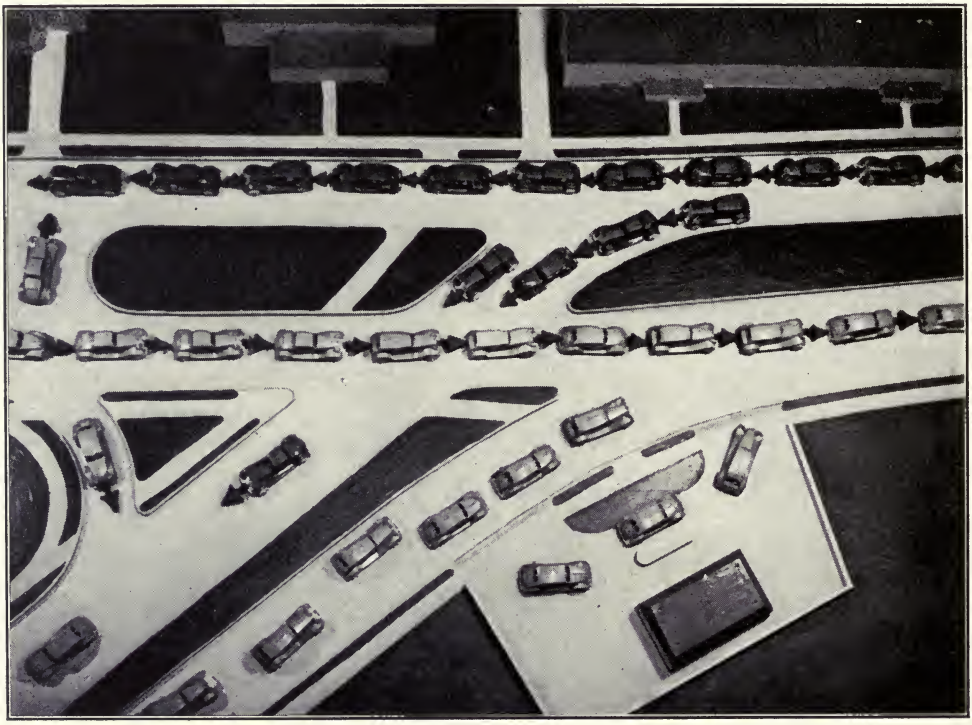
Large open areas produce large confusion areas.

30 degrees. From this point until the right-angle intersection of 90 degrees is reached, there are intermediary angles which give difficulties, apparently because the operator in one approaching stream is forced to look over his left shoulder in an awkward position to see traffic approaching from his left. The right angle provides the maximum of visibility but permits practically no lateral adjustment for "weaving" or merging. The angle beyond 90 degrees becomes increasingly difficult until a point is reached where an angle approaching a head-on collision is the result.

It is a reasonable assumption that the human being is able to judge one

angle much better than another. The fewer the elements in his formula, the better will be his decision.

In studying angles of movement, it is noted that they make a great deal of difference in the speeds and speed differentials which must be considered by each motorist. For example, if two lanes of vehicles are approaching each other at an angle of less than 30 degrees, and the speed of one is 50 miles per hour while the speed of the other is 40 miles per hour, the operator of one vehicle is concerned with only a fairly simple angle and



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Channelizing islands reduce open areas, control angles and speed, and give the pedestrian short jumps to cross the intersection.

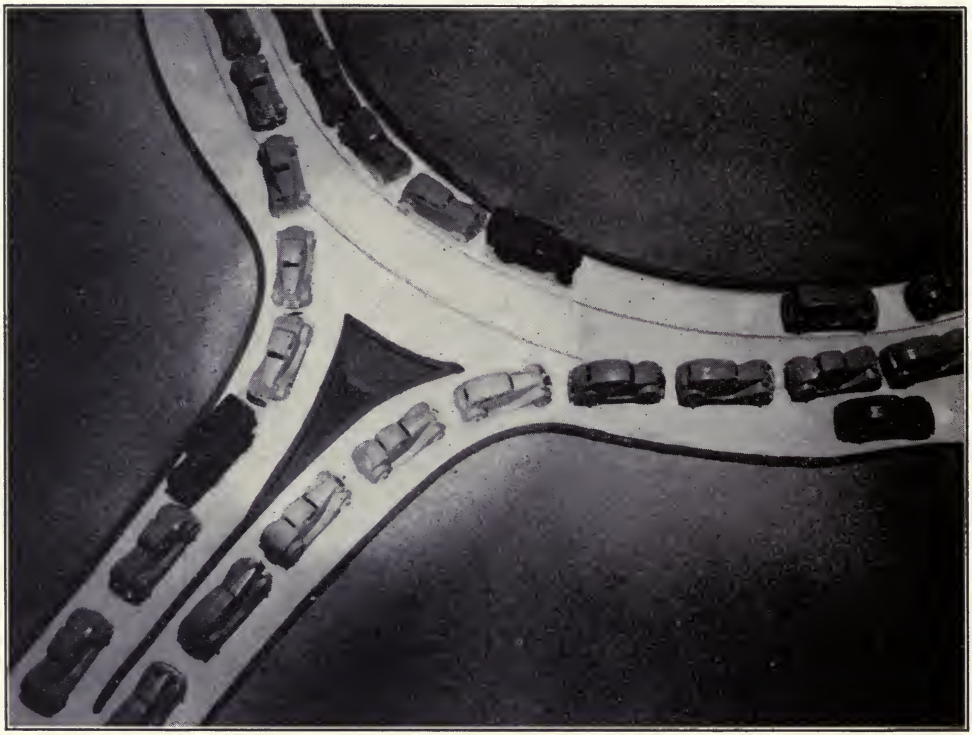
with a differential of approximately 10 miles per hour. On the other extreme, assuming the same velocities, but at an angle which produces almost a head-on collision, one operator is faced with an angle which makes it exceedingly difficult for him to judge the speed of oncoming traffic. Furthermore, he is confronted with the measurement of a total speed differential of approximately 90 miles per hour. Naturally, he is much less able to analyze the second problem accurately than the first.

Hence it would appear that every effort should be made to merge traffic at an angle of less than 30 degrees. If this is impossible, 90 degrees may be the next best acceptable angle. Particular effort should be made to avoid the angle which produces almost a head-on movement; it is the most dangerous angle of all and is the chief reason why the "Y" type of intersection is probably unsound.

Principle 74

LARGE OPEN AREAS OF ROADWAY SURFACE AT INTERSECTIONS MUST BE REDUCED TO CHANNELS OF TWO LANES OR ONE LANE. Islands Must Be Used to Control the Path and Movement of Each Vehicle.

Motorists are not very good at guessing at the paths of other vehicles, even if such paths are reasonably restricted. When the opportunities for different paths are great, accidents are inevitable.



Bryant Burkhard.

Throats should release entering traffic at the desired speed and angle.

When the original two-lane highway was almost universal, it was not difficult to keep the motorist on his side of the road, because the necessity for it was obvious. When highways were widened this became a problem. In many places, particularly at intersections and squares, there was too much room; the motorist wandered about, his movements became irregular, and each operator had difficulty in guessing what the other was going to do.

This illustrates another principle of traffic control—that as little choice

as possible should be left to the discretion of the operator. The element of discretion is a variable, and high speeds demand a constant. The aim should be to give the motorist only enough room to guide him and prevent him physically from doing the wrong thing—practically to put him on rails.

Traffic islands in the past have had a rather doubtful reputation, largely because of poor design, poor location, and, especially, poor illumination. For this reason it has taken some time for the traffic engineer to realize the potentialities of islands in the control of traffic. Raised traffic

Bryant Burkhard.

The entering traffic at rotors causes trouble.

islands should be placed in the areas which are not normally used (as shown by snow patterns or headlight pictures), so that they will not be in the way of the correct movement of traffic. In many places they can be more effective than any other type of control and at much less expense and delay to the motorist.

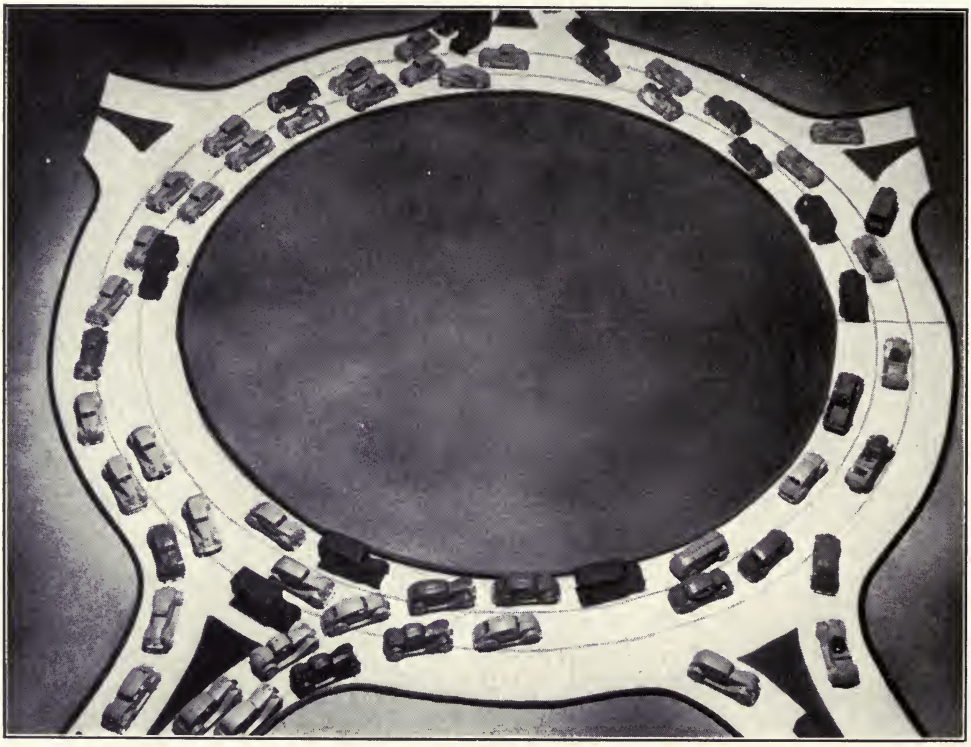
The average motorist is not capable of dealing with more than one car pattern at a time. Two lanes appear to be his practical efficient maximum. He can deal with a car on his left or a car on his right, but a car on both his right and his left tends to get him into difficulties.

Principle 75

INDIVIDUAL MOVEMENTS MUST BE CONTROLLED.
Wherever Possible, Individual Lanes for Single Lines of Traffic Must Be Established.

Never more than two free lanes are advisable under most conditions, and in special cases single lanes are desirable.

When traffic becomes sufficiently heavy to warrant multi-lane highways and intersections with wide throats permitting three entering lanes of traf-



Bryant Burkhard.

Rotary traffic depends upon weaving for success, and all angles must be controlled.

fic, it is important but rather difficult to keep the vehicles in their respective lanes. Paint lines are valuable, but often they are disregarded. It then becomes necessary to use the next stronger medium, the button, and eventually the raised island. Future intersections, except where rotary traffic or grade separations are provided, may resemble slot machines by which vehicles will be forced into their proper lanes and signaled through on short cycles and in closely coupled platoons. This is common practice today near toll booths.

As has been indicated, when the roadway becomes wide enough to permit two lanes in each direction, a raised medial strip is usually advisable. When the roadway becomes wider still, particularly if loading and unloading take place or if a main highway passes through a small village, service drives separated by raised strips should be built for slow local traffic.

Passing becomes dangerous on curves and hills if, in order to overtake, vehicles pull over to the left side of the highway in the face of oncoming traffic. Here again it is possible to separate the two directions by a raised medial strip, thus making it physically impossible for the motorist to drive

Bryant Burkhard.

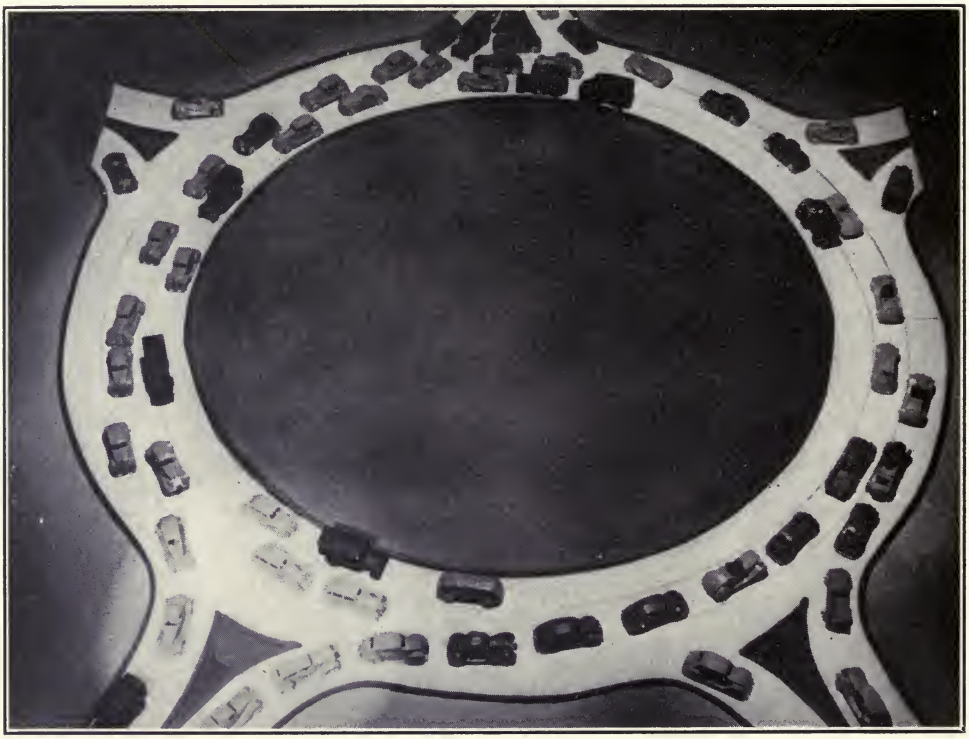
Where many roads come together the principle of the rotor has special value.

over on the wrong side of the roadway. Grade separation efficiency can frequently be assisted by means of raised medial strips. This is particularly true of the part which goes over the top where a grade exists. Actually the raised medial strip can be used to advantage on every hill and curve where visibility is less restricted.

The principle of channelization is particularly important where large open areas exist and where a large number of different movements must be segregated and brought together at particular positions and angles.

If motorists know that the paths of all other vehicles are completely controlled and that these paths cross or merge or diverge only at predetermined points, much confusion would be avoided and accidents and delay would be reduced.

One-lane designs should, of course, be used only where passing is prohibited, as at places adjacent to intersections and vertical or horizontal curves. At these points the introduction of physical lane dividers would serve automatically to enforce "no passing."



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The diameter of the rotary traffic island has a major bearing on the speed around the rotor.

In the earlier days of automobile manufacturing, one-lane channels could not be used because of the possibility of mechanical failures. Under present operation such failures are negligible in number. Furthermore, since the lane separators would be of a type which could be easily mounted, passing in emergencies could take place with adequate safety.

Such devices will naturally bring with them construction and maintenance problems, particularly in regions of ice and snow. However, if the principle is sound and increased efficiencies can be demonstrated, the added efforts would be well worth while.

Principle 76

FUNNELING OR CONDENSING LANES SHOULD BE PROVIDED. Special Arrangement Should Be Made Wherever It Is Desired to Reduce the Number of Lanes.

The physical design which accomplishes the weaving process to reduce the number of moving lanes of traffic is known as "funneling."

Frequently the total width of the highway needs to be contracted or expanded in accordance with volume requirements or because of barriers which cannot be immediately removed. Under these circumstances it is necessary to reduce a multiple-lane highway to a two-lane highway. It is believed that this can best be accomplished through the following steps:

Speed Reduction Should Come First. It is generally accepted that the weaving distances for higher speeds are greater than for lower speeds, and that the difficulty of weaving decreases as the speed decreases. Thus the first step in reducing the number of operating lanes should be to lower the speed of travel by signs, signals, markings, islands, or curves.

High-Speed Lanes Should Be Favored. The form of the funnel should be non-symmetrical. It should be of such design that the vehicles in the high-speed or left-hand lane will go straight ahead, while the slow-speed vehicles in the right-hand lane will be forced by design to merge with the high-speed lane.

Length of Funnel Depends upon Speed Desired. The higher the operating speed desired, the longer the funnel will have to be, and the more "recovery area" must be provided.

One Lane Should Be Merged at a Time. It is well known that the motorist performs more satisfactorily if he deals with only one moving lane at a time. If several lanes of traffic merged simultaneously, considerable confusion would probably result.

Condensing Should Be by Stages. It is advisable to reduce the number of moving lanes by units of two lanes. A six-lane highway should first be reduced to a four-lane highway, and the next funneling process should not be undertaken until this merging action has been completed. The four-lane highway should then be reduced to a two-lane highway. This process will lessen the confusion area, particularly with reference to vehicles forced to make a left or right turn at an adjacent intersection.

The Speed and Angle of Weaving Should Be Controlled. Design should definitely establish the angle of weaving and the differentials in velocity at the weaving points.

Weaving Undesirable on Curves. Funnels should be established only where all vehicles are moving in practically a straight line. If a funnel is

bent or placed on a curve, the operator is confronted with two different situations simultaneously. The addition of centrifugal force will reduce the efficiency and safety of weaving.

Storage Capacity. At entrances to bridges, tunnels, or bottlenecks which markedly reduce speed, funnels should be lengthened to provide storage capacity for momentary peaks.

Principle 77

THE PATHS OF TURNING MOVEMENTS MUST BE CONTROLLED BY THROAT LANES SUFFICIENTLY NARROW, LONG, AND SHARP TO REDUCE SPEED TO THE CRUISING SPEED OF THE STREAM WHICH IS ENTERED, AND TO FORCE THE ENTERING VEHICLES TO MERGE AT THE DESIRED ANGLE. If Entering Throats Are Short and Two Lanes Wide the Operator Is Tempted to Select the Maximum Radius, thus Increasing His Speed of Entry and Permitting an Unfavorable Angle of Merging.

Turning vehicles cause an abnormal proportion of accidents; therefore control should be centered on them. Left turns cause difficulty because there is a tendency to cut the corner and to fight for the right-of-way. Right turns interfere with pedestrians. The danger from both movements is increased when motorists fail to get into the proper lane from which to make the turn.

The original theory of handling left turns was to require the passage of the vehicle around the center of the intersection. This resulted in eight points of conflict and exceedingly sharp turns. Although the theory and practice have long since changed, several states still have laws requiring the old turn.

The generally accepted practice is that the left turns should be made around two of the four points formed by the intersection of the street center lines and the property lines. This reduces the points of conflict to four well-separated points and provides a much larger turning radius. This turn may be indicated by markings at the four points. Since many motorists fail to obey the paint lines, it may be necessary to make the regulation somewhat self-enforcing.

The first step in this direction is the introduction of raised buttons, which will give motorists who disobey the regulation a decided bump. This is supplemented by paint lines leading up to the buttons. When this is not sufficient, a row of buttons is installed.

The next development is to build a raised island to serve the same function. This island has many advantages over the button and is useful in a variety of ways. In addition to its channelizing value it serves the pedestrian as a place of refuge and permits him to cross the street in two "jumps" without being caught in the middle between two lanes of moving traffic. Obviously the turning radius is determined by the islands, and the speed of the turns can be controlled by moving the islands into or out

of the intersection. The farther into the intersection the control islands are placed, the sharper will be the turning radius and thus the slower the speed. The narrower the channel, the more will the direction be controlled.

At some intersections right turns are so numerous that they warrant special designs. One rather effective design is the separate roadway permitting movement at all times except when pedestrians are present.

On entrances and exits to rotary traffic or grade separations two-lane entrances and exits of a curved nature have seldom proved efficient. In rare instances vehicles have actually entered or left in two simultaneously moving parallel lanes. This is usually because the increased width has made it possible for the driver to increase his radius by encroaching upon another lane. This produces a "pinching" action which practically reduces the two-lane entry to the efficiency of one lane. Because of the improper lateral placement of the vehicles, this pincer action either produces one lane of movement or causes accidents. In addition, when two vehicles do enter at the same time one hides the other from traffic trying to merge from the left. Overtaking and passing in two-lane throats is the cause of much difficulty. This is another example of the ineffectiveness of paint lines in controlling vehicle paths.

It is suggested that, where entering or leaving capacity requires more than one lane, two separate and distinct one-lane entrances or exits be provided, or that the two-lane entrances and exits be physically separated by a low mountable curbing which can be crossed in an emergency. Only by the single-lane entrance or exit can maximum control of the angle and speed of entrance or exit be obtained.

Principle 78

ACCELERATION AND DECELERATION LANES ARE ESSENTIAL IF CRUISING SPEEDS ARE TO BE MAINTAINED. If Vehicles Are Permitted to Enter or Leave the Traffic Stream at a Speed Lower than the Cruising Speed of the Main Traffic Flow, Dangerous Attempts to Pass Will Be Made. If It Is Desired to Maintain a Reasonably Constant Cruising Speed on a Highway It Is Essential that Every Single Entrance and Exit Be Provided with Accelerating and Decelerating Lanes.

One of the fundamental causes of traffic difficulties is the difference between the speeds of vehicles operating in the same lane. Since at most intersections it is necessary for drivers to slow down to turn off the roadway, and equally necessary to make the turn at a slow speed—thus having to speed up before merging with traffic—special provisions must be made for these functions. Otherwise vehicles slowing down to turn will dam up traffic behind, with the result that impatient drivers will attempt passes under hazardous conditions. If vehicles are permitted to enter a roadway in front of high-speed traffic, it will either cause emergency stops with their attending error and accidents, or encourage dangerous passes.

If this principle is sound, it applies to all entrances and exits to highways, including those from private property. Though this may seem a wide application, the numerous accidents caused by people entering and leaving filling stations, eating houses, and amusement places should be ample evidence of its importance.

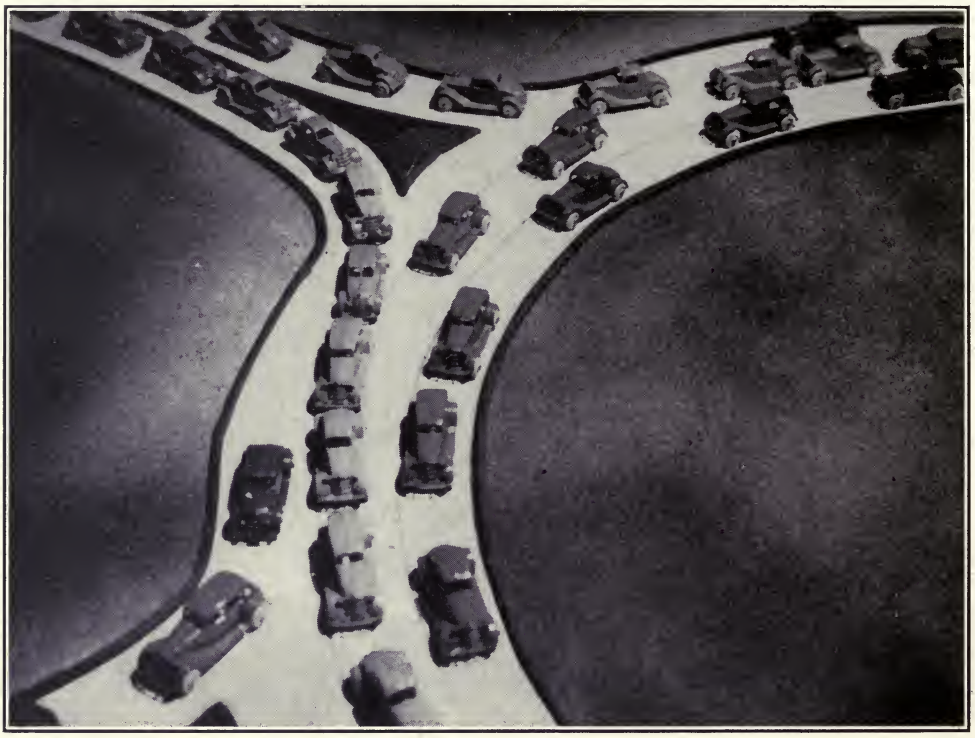
The solution to the problem of entering and leaving traffic lies in the provision of an additional lane on which the driver, prior to making his turn, may slow down out of the main traffic, and on which the entering traffic may speed up before moving over into the cruising lane.

The length of accelerating and decelerating lanes depends primarily upon velocity; the higher the speed, the longer the lane must be. Unfortunately, in the past most accelerating and decelerating lanes have been so short that they have not offered sufficient inducement to the motorist to take advantage of the principle which they represent. The difficulty is not with the motorist but with the design.

The tapering of the beginning of an accelerating or a decelerating lane is dependent on speed and must approximate the 60-to-1 ratio stated as a minimum for lateral movement requirements. Even though ample distance is provided for the design speed, some motorists will ignore the new facility and attempt to do their slowing down or speeding up in the cruising lane.

Some motorists do this from habit and others by selfish intent. Whatever the cause, specific provision must be made to prohibit such violations by the installation of low islands which will definitely limit the available area for entering or leaving. This would also prevent right-side passing by impatient motorists and subsequent pinching.

These lanes may have straightaway sections or spiral curves, or both. The choice hinges primarily upon the terrain and available intersection area. Some engineers believe that the straightaway area has some advantage under



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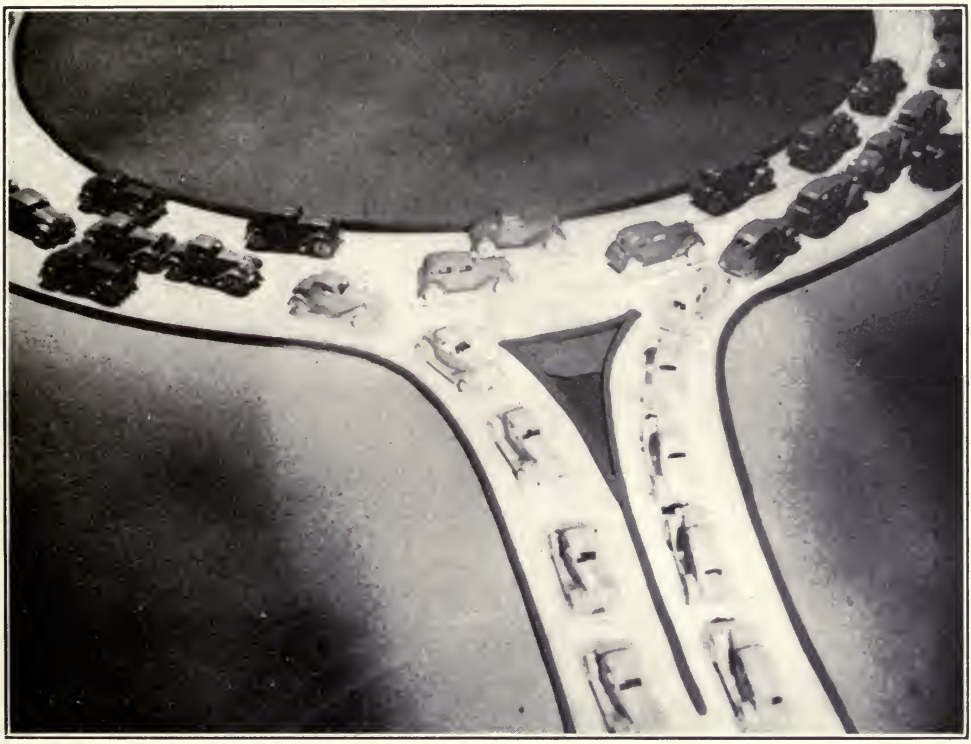
The distance between entering roadways controls the weaving distance.

ice conditions because a good part of the slowing down may be accomplished without the complicating factor of centrifugal force.

Even with the provision of an accelerating lane, it is still necessary for the motorist to await an opening in the traffic flow at the proper time and of sufficient length to permit him to merge safely. Obviously he must be able to view approaching traffic in order to discover his opportunity. Hence he must be brought along for at least a short distance to where he approaches the main flow at right angles. At such a point he is in the best position to view the main flow prior to turning right and accelerating.

A proper decelerating lane may be classified into three parts: (1) the entering part, which must have a transition adequate for the designed speed of the roadway; (2) the slowing-down part, which must be adequate to permit the motorist to reduce his speed prior to making his turn; and (3) the turning part. Sometimes parts (2) and (3) may be combined if adequate intersection area is available.

The decelerating lane built on a spiral curve may be superior, because it gives the motorist a more effective impression of a "curve" and exit and



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Lanes of rotary traffic islands must be adequate to handle the capacity of the entrances.

the transition will be more effective. This advantage might more than offset ice conditions when there is available area.

The accelerating lane may be divided into four parts: (1) the turning or viewing point at which the motorist makes his decision as to the availability of an opening in the main flow; (2) the accelerating part, which must be of sufficient length to permit the motorist to reach the design speed of cruising cars on the main lanes; (3) the weaving or merging part, which must be of sufficient length to permit the motorist to adjust his thinking in

accordance with the available openings; and (4) the safety or recovery part, in which the motorist may have an opportunity to reduce his speed and come to a stop if the opening is preempted and is thus no longer available. At such a point, the so-called "last fair chance island" may be utilized.

Where speeds of 50 or 60 miles an hour prevail, acceleration and deceleration lanes probably should be at least 1000 feet in length on level roadways. From the viewpoint of convenience and comfort, this length would need to be considerably increased if the motorist was to do his decelerating entirely by the braking power of his motor, particularly on down grades, which obviously would be more popular than to require use of the brakes.

The frequency of intersections with these special lanes along the roadway will eventually determine when a four-lane stage is reached and when it would become more economical to provide four lanes for accelerating and decelerating purposes. However, as the volume on four-lane roadways increases, the function of accelerating and decelerating would have to be provided for by the addition of a fifth or sixth lane adjacent to each intersection.

The principle of making special provision for slowing down and speeding up at intersections appears to be sound. As the provision of accelerating and decelerating lanes requires a change in driving characteristics, it is important that the early treatment be overdesigned in order to guarantee successful operation. Because this subject is so new and so few facts are now available, special research is strongly recommended.

Principle 79

ROTARY TRAFFIC CIRCLES INCREASE CAPACITY. Over-All Speeds around It Are Low, and Pedestrian Crossing Possibly Is Made More Difficult, but Circles Appear to Be a Good Solution at Points Having Favorable Characteristics.

When it is apparent, even before a highway is built or rebuilt, that it is going to carry heavy traffic and have heavy crossings, provision should be made to bring the capacity of the intersections up to that of the rest of the highway.

The installation of a rotary traffic system is one way of accomplishing this. The design is slightly complex and should be varied to fit each individual intersection. It is important that the radius be sufficient to permit the necessary weaving. Actually the rotors should not be round except when the flow of traffic on entering roadways is equal. The heavy traffic should be detoured less than the lighter traffic. When the cross flow is comparatively light, the rotor should be elongated and should resemble a piece of normal raised medial strip. If it is agreed that the heavy traffic should have a proportionate advantage over light, the elongated rotor principle can be used to prevent the direct crossing of many lightly traveled crossroads.

The space between entrances will control the weaving distance, and this in turn will limit the capacity.

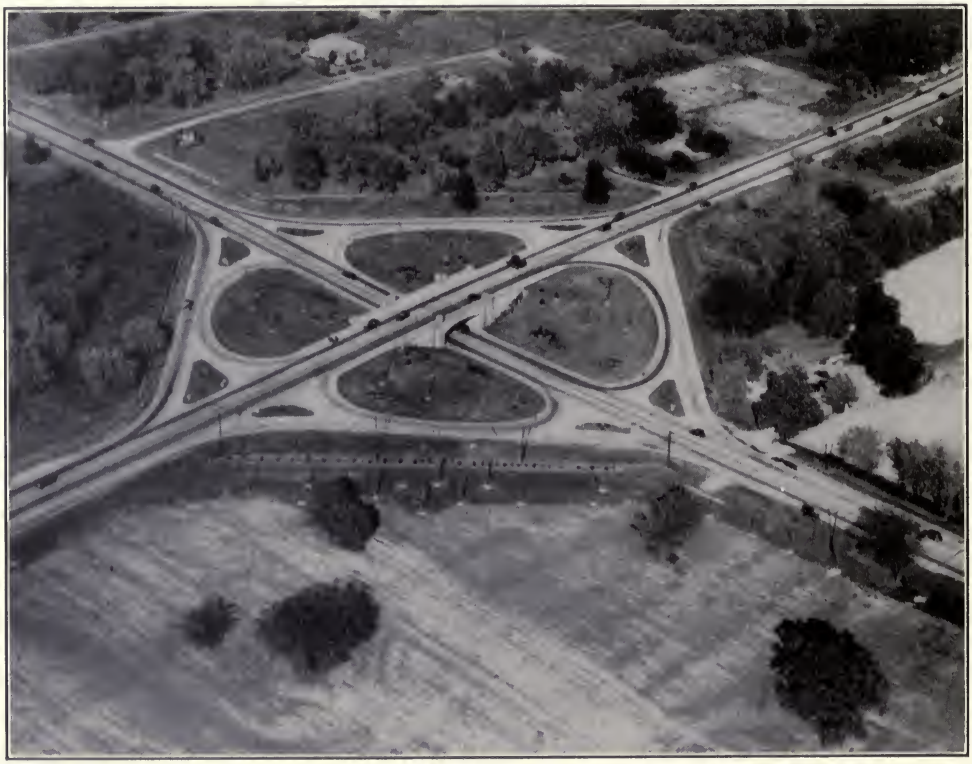
The radius and superelevation will control the speed of movement around the rotor. When this speed becomes less than 20 miles per hour a difficult problem arises in reducing the approach speed to within 10 miles per hour of the speed around the rotor.

The entering islands are a vital part of the design, since they must control the speed and angle of entrance.

Principle 80

GRADE SEPARATION INCREASES CAPACITY AT HIGHER SPEEDS THAN ROTARY TRAFFIC CIRCLES. It Must Be Simple and "Natural" in Design. Choice of Direction of Movement Must Be Narrowed down, Particularly at Multiple Intersections.

The separation of grades gives the intersection almost the same capacity as the roadways which bring traffic to it. Since it removes most conflicting



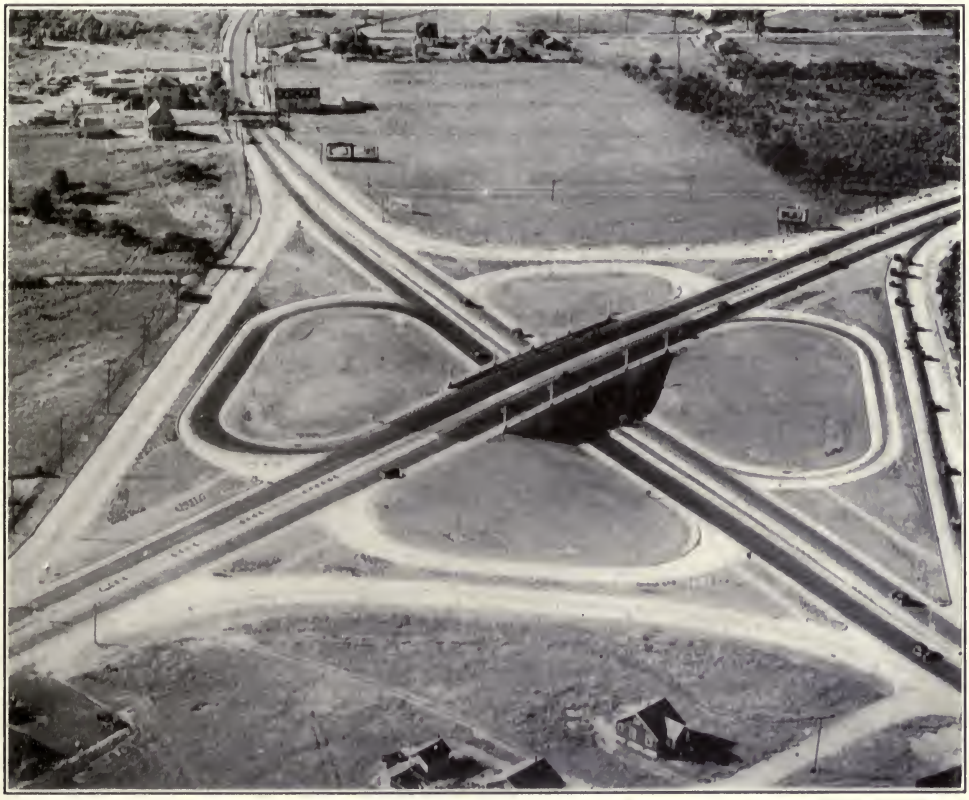
Courtesy Missouri Highway Department.

Grade separations carry traffic at high speed. Note oil pattern of left turn impinging on path of right turn where two-way movement without separation is permitted.

movements, it naturally reduces accidents. The number of approach provisions for turning movements must be determined by flow requirements, but the approaches should be so built that they can be added to as traffic increases.

One of the inherent difficulties of most existing grade separations is that

the motorist approaching one and wishing to turn is faced with too many decisions. The exits he must not enter should be so designed that it is almost impossible for him to enter them. The points of entrance and exit should be as widely separated as practicable. There is a growing demand for a new system of signs to explain the turning movements, and the best principle



Courtesy New Jersey Highway Department.

Oil patterns show proportionate use of turning facilities.

is apparently to place a diagrammatic supersized sign in advance of approaches, and directional signs only at exits.

It is especially important that sufficient land be obtained at intersections to allow for future construction of grade separations, rotary traffic islands, or a combination.

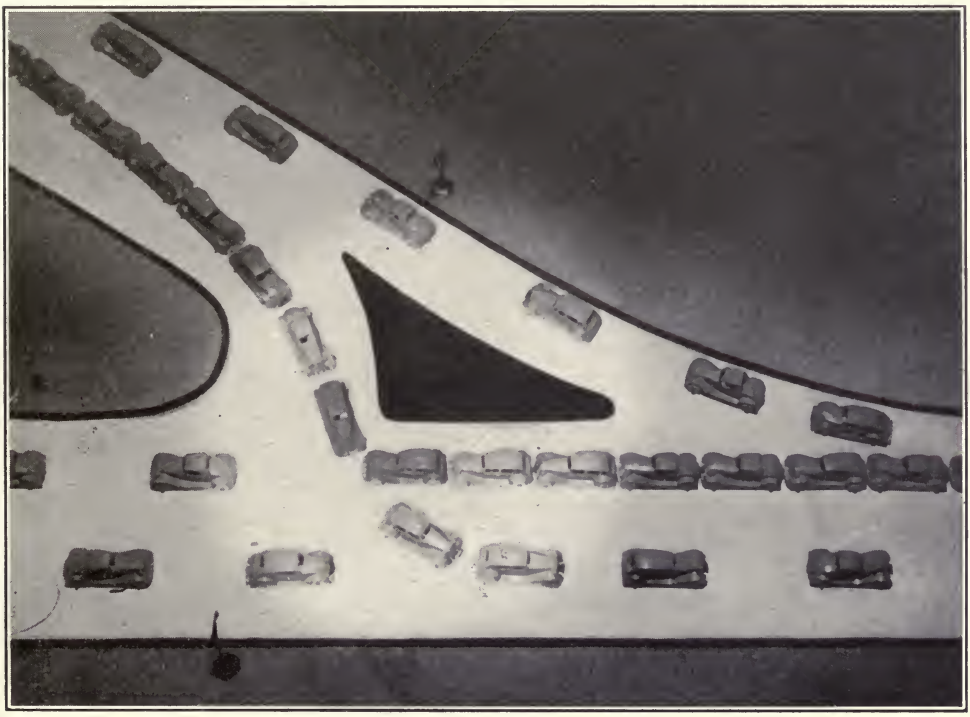
Courtesy New Jersey Highway Department.

Traffic distributors may look complicated from the air but they present the driver with only one decision at a time.

CHAPTER XIX

TRAFFIC ISLANDS

In this chapter attention is focused upon the island as a tool of the engineer in limiting and controlling the paths of moving vehicles and in protecting pedestrians and the waiting vehicle. In a very real sense traffic



Bryant Burkhard.

Lamb-chop type island to prevent the cutting of left turns.

islands are to free-wheel vehicles what rails are to railroad trains and street cars. Because of human limitations they have a vast potential for improvement through dictating direction, simplifying conflict points, and reducing driver decisions.

Their uses, width, location, and front-end protection are treated in seven sections.

TRAFFIC ISLANDS HAVE NUMEROUS VALUES IN TRAFFIC CONTROL. These Values, under Most Conditions, More Than Offset Increased Maintenance and Snow-Removal Costs.

A traffic island is an area from which vehicles are excluded. In some instances this exclusion is made complete by a physical barrier. In others,

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Island converts head-on angle into right angle.

traffic is prohibited from using the island under normal circumstances, but may mount the low curbings in an emergency. The chief functions of traffic islands are to control the direction and lateral placement of vehicular movement and to provide loading, unloading, or waiting spaces for pedestrians.

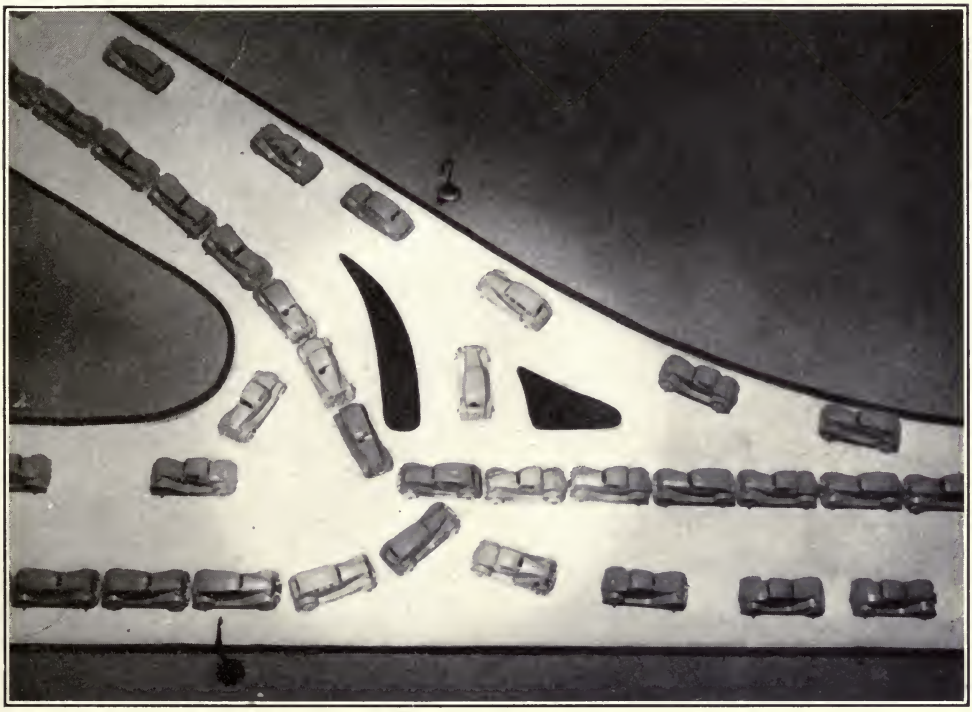
The following are among the more important applications of traffic islands:

Pedestrian Islands. These are used at points where the pedestrian would otherwise be forced to cross more than two moving lanes of traffic at

one time, or as a place where he may stand while waiting to enter or after leaving a streetcar or bus.

Left-Turn Islands. These are used to enforce by physical means prohibiting vehicles from cutting corners or making left turns.

Medial Dividers. These are utilized to separate traffic moving in opposing directions and can be designed to prevent indiscriminate left turns.



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Two islands may assist two left turns.

Right-Turn Islands. These are employed to create a separate channel for right-turn movements.

Dead-Area Islands. These are installed to fill in the dead area at intersections. They are also located at other places where, because of the design, there exist areas which are not sufficiently large for planting, yet which should be set aside and prohibited from vehicular use in order to define clearly the channels of movement.

"Last Fair Chance" Islands. These are incorporated in the design to control the paths of movement of vehicles under normal conditions, but are so laid out as to give the motorist an opportunity to recover from an emergency by driving upon the island without having to impinge upon the move-

ment of vehicles in the normally accepted operating lanes. This type of island should be lower and easily mounted.

Location for Traffic Sign or Signal. Traffic islands often form a particularly satisfactory location for mechanical control equipment and lighting units.

Traffic islands are considered an exceedingly valuable tool of the traffic engineer. In the past, traffic islands received much criticism, mainly because

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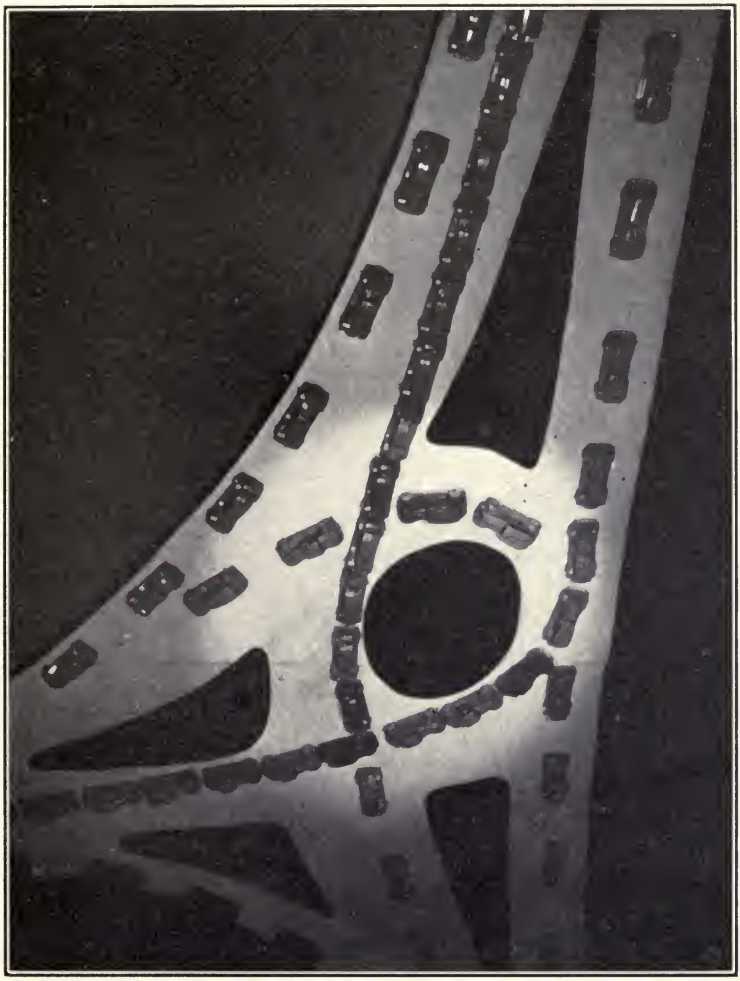
Area still too open to provide full control over angles.

of improper location, inadequate illumination, and physical characteristics that severely damaged motor vehicles which struck them. These misuses, however, cannot detract from the very real value of properly designed islands as channelizing tools. Traffic islands may involve additional maintenance and snow-removal costs, which, however, must be set off against the gains they produce. If net gains can be shown, islands should be used regardless of their effect upon maintenance and snow-removal costs.

Principle 82

LOADING ZONES AND PEDESTRIAN PROTECTION ISLANDS MUST BE USED. The Pedestrian Cannot Cross More than Two Moving Lanes Safely at One Time.

The pedestrian is becoming an increasingly difficult problem. It is obvious that, the greater the distance he has to go in crossing the street



Bryant Burkhard.

Five islands control two left turns, shadow waiting vehicles, and protect one right turn.

or highway, the more hazard exists. The introduction of islands is beneficial because it reduces this distance by breaking it up into smaller parts. There is demand for research to determine the maximum width which should be

permitted. It is quite possible that such a study would show that one or two lanes are all that the pedestrian should be required to cross at one time without protection.

Two lanes of one-way movement are satisfactory, but two lanes of two-way movement are much more difficult.

If a pedestrian is left standing long enough in the street amid fast and heavy traffic, something is going to happen to him. It is unreasonable to ask him to step off the curb unless some protection is afforded him. In

Bryant Burkhard.

Islands have produced two right angles and one flat angle instead of two head-on collision angles.

addition, whenever a streetcar unloads without an island, vehicular traffic is held up, even though an officer or traffic signal may indicate a "go" period. Thus if there is enough traffic to warrant it and enough room to install it properly, a loading zone should be installed.

The full application of this means that at *every* intersection having more than two lanes, one or more lanes in each direction, and where pedestrian volume or accidents warrant, there should be one pedestrian island

for each entering street. This would include all streets over 56 feet from curb to curb, for otherwise the pedestrian would have to cross more than two lanes at one time and would frequently be caught between moving lanes of traffic. Wider streets than this should probably have additional islands, particularly when there are complicated turning movements.

It would also mean that all streetcar stops (under similar warranting conditions) should have streetcar loading islands.

It seems reasonable to believe that the pedestrian will benefit by having shorter "jumps" to make and by knowing exactly where the vehicular stream will cross. If vehicles have latitude in their paths, the decision of the pedestrian is much more difficult, particularly regarding turning movements.

The fact that pedestrian islands, under most circumstances, also contribute materially to the efficiency of moving traffic is an added reason for their installation.

Principle 83

THE MOST DESIRABLE WIDTH OF A MEDIAL DIVIDER DEPENDS PRIMARILY ON THE SPEED OF TRAFFIC, THE AVAILABLE RIGHT-OF-WAY, AND PROVISION FOR LEFT AND "U" TURNS. Unless the Medial Divider Is of Such Width or Barrier Character as to Provide for Speed and Turns, It Will Not Contribute Much to the Improvement of the Traffic Facility.

To guarantee a prohibition of head-on collisions at high speed a divider should be approximately 50 feet wide; less than that would permit a car to

Sanborn.

Three islands have created four one-way entrances and exits and a good vision intersecting angle.

cross it quickly and cause a head-on collision. With 50 feet a car would probably have sufficient space to maneuver and come to a stop. Under these circumstances a low, easy-to-mount curb may be used. As the width of the island is reduced, the necessity for an actual physical barrier increases.

When the width is reduced to 20 feet a minimum for left turns has been reached.

There is a presumption in favor of a "parabolic deflector" when the point is reached where the width cannot absorb the speed. Open areas designed to absorb the speed should never be planted with large trees, as these would almost surely produce a serious accident if struck by a car forced off the road. Since rear-end collisions are nowhere near as likely to be fatal as

Dave Packwood.

Slow speed treatment reduces large intersection area.

head-on collisions, it is believed sound to force cars back on the road if sufficient lateral area is not available. Shrubs, however, are highly desirable to cut off headlight glare, keep out pedestrians, and stop cars out of control.

Where it is unlawful to pass if this requires crossing the center line, and where violations do in fact cause fatal accidents, it may be sound to enforce the law by making it physically impossible to cross the center line. In extreme cases, this might be applied to two-lane highways.

In built-up areas where property values are high and where pedestrians

and turning movements are not involved, the small "parabolic deflector," taking only 30 inches with about a 15-inch clearance on each side, would require only a total width of 60 inches. This 5 feet, in comparison with a 50-foot divider, would represent a saving of 45 feet—an enormous saving in cost.

From the esthetic viewpoint, much greater widths are desirable, as they permit attractive planting. If each pair of lanes is treated separately it is

Bryant Burkhard.

Island provides excellent location for information sign.

frequently possible to save existing trees or bushes by adjusting the width of the center strip to the situation.

In rolling country, roadways may be more accurately fitted into the hills and valleys if each set of lanes is treated separately. Where cuts are required, the middle strip may sometimes be provided very economically by placing each pair of lanes at a different elevation.

It has been argued that a wider medial strip would force the use of two sets of lighting poles instead of one, thus increasing the cost. This, however, must be balanced against the hazard of having a dangerous fixed object on the island.

The effect on the cost of bridges of widening the medial divider must also be studied carefully. Single-span limits and center supports must be balanced out.

Where additional lanes are to be added, the middle strip should be wide enough to provide for them at a later date. New two-lane highways should be located on one side of the adequate right-of-way, so they may be adaptable to a middle strip and two more lanes at a later date.

Principle 84

IT IS PREFERABLE TO START MEDIAL DIVIDERS ON TANGENTS AND AT INTERSECTIONS. Medial Dividers if Improperly Placed May Cause More Accidents than They Prevent.

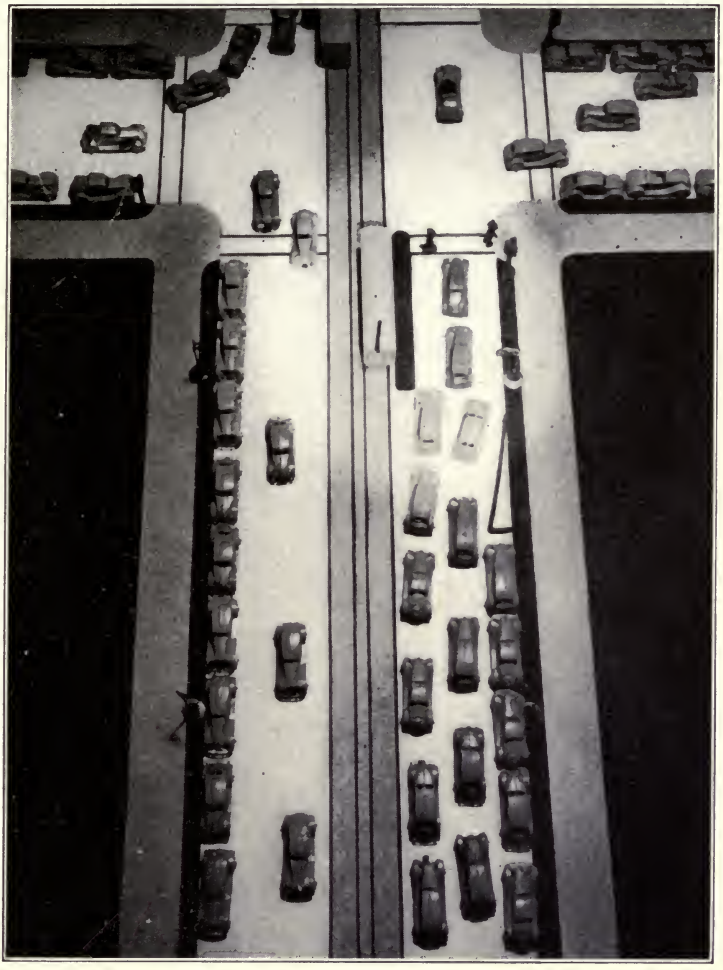
Structures in the middle of the road should never be placed with their front ends on a curve, particularly if that end is on a direct line with the

Bryant Burkhard.

Loading island and physical barrier discourage parking adjacent to the island.

natural path of a vehicle going in a straight direction. They should always be carried around or over the curve until they are past the point of tangent.

The reason is that, if the front end is on the curve and the driver fails to make the curve properly, he is certain to hit the end of the island. If, on the other hand, the front end of the island is brought around the curve to a point a reasonable distance beyond the point of the tangent, the operator, in the course of his normal movement, would not hit the end of the island.



Bryant Burkhard.

The two-lane channel between the loading zone and the curb is hard to use efficiently.

In fact, he would have to make a deliberate and unnatural turn into the island.

Locating the beginning of an island at an intersection is advantageous because it helps to reduce speed and control left turns.

The critical point of a traffic island is the end nearest approaching traf-

fic. Once traffic has been successfully led parallel to the island, comparatively little difficulty will be encountered.

It is also important that islands be located so that their advance ends are visible for a considerable distance ahead. This means that the beginning of islands should not be located just the other side of curves or just over the brow of hills. In general, this sight distance requirement applies equally to all traffic control mechanisms or devices. A common example of this difficulty is a highway underpass going below railroad tracks. With earlier construction, the dip produced was quite severe. Where supporting columns were used, they were "surprises" to the motorist. Attempts were made to solve this problem by providing a short island in advance of the supporting member. But the situation was not improved until the island was extended over the brow of the dip to where it could be seen for a considerable distance ahead.

NO TRAFFIC ISLAND SHOULD BE LOCATED SO THAT THE FRONT END IS IN LINE WITH THE NATURAL PATH OF APPROACHING VEHICLES. All Islands Should, Wherever Possible, Be so Located that Their Front Ends Are Past the Point of Tangent and Offset from the Nearest Approaching Lane.

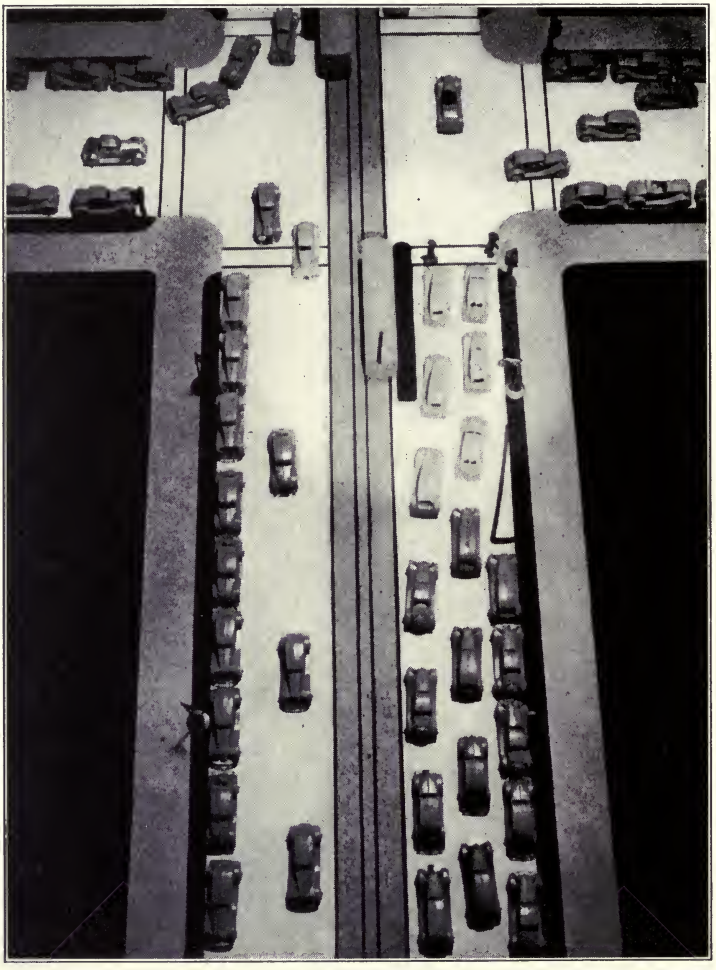
If islands are located so that they lie directly in front of the natural path of vehicles, they will almost certainly be hit. Errors of judgment or distraction will prevent the operator from observing the island until it is too

Bryant Burkhard.

One stopped vehicle blocks one full lane.

late, and restrictions on visibility such as rain, snow, or darkness will reduce advance warning.

Where islands are located in the middle of the road, their advance ends should be offset so that they do not lie within the limits of a well-established lane of approaching traffic.



Bryant Burkhard.

Two lanes can move if outside-lane car does not cut in toward the curb and block curb lane.

If islands must be placed on curves or adjacent to elements which may alter the movement of vehicles, a careful study must be made of the natural path in order to be sure that the front end of the island does not obstruct it.

An interesting example of this principle is found in the location of

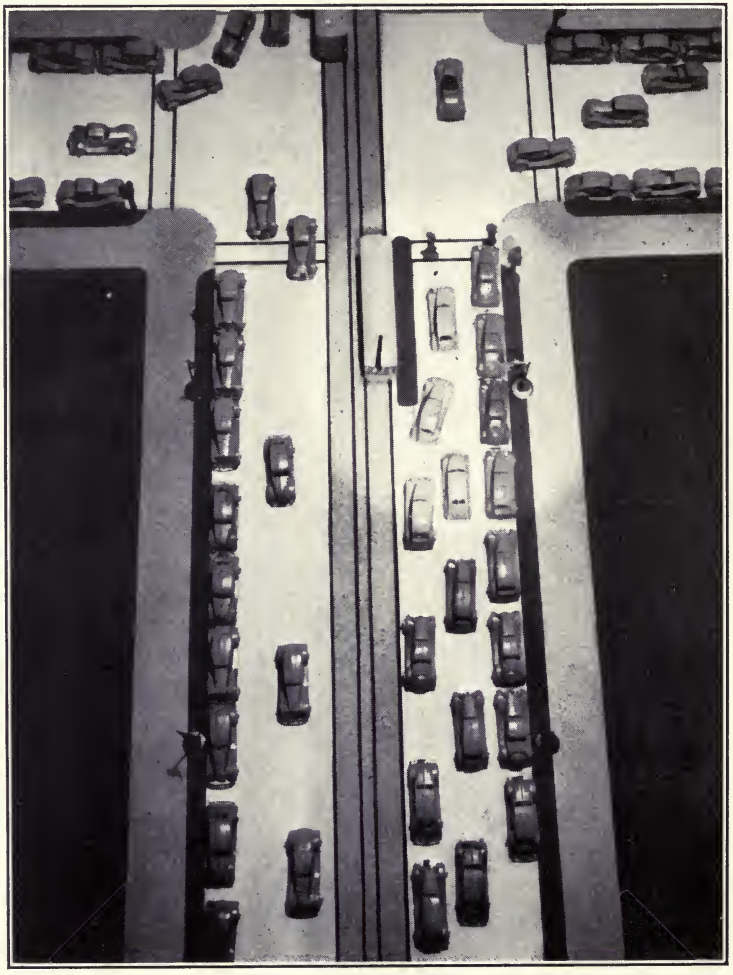
culvert heads just beyond the beginning of curves. This location is on a direct line with the tangent of approaching traffic. If, for any reason, the operator fails to see the hazard and continues in a normal straight direction, he will strike the abutment. Abutments so located will be hit far more frequently than abutments which are not placed directly in the line of approaching traffic.

In the earlier days of construction, the placing of culverts and abutments was determined almost entirely by drainage requirements. Under modern operating conditions, the controlling factor in the location of such culverts and abutments should be the movement of vehicles rather than the requirements of drainage, which, after all, usually may be altered physically without greatly increasing the cost.

Principle 86

TRAFFIC ISLANDS WHICH LIE WITHIN THE NATURAL PATH OF VEHICLES MUST HAVE FRONT-END PROTECTION COMMENSURATE WITH THE SPEED OF APPROACHING CARS. Otherwise the Island Will Become a Hazard.

Front-end protection should have elements appealing to as many senses as possible—sight, hearing, and feeling. Lane islands need as much front-end protection as medial dividers, sometimes more.



Bryant Burkhard.

Illegal parking at corner cuts capacity when coupled with loading zone.

The eye may be appealed to by:

1. Widened paint lines.
2. Lines of delineation.
3. Raised rubber flaps simulating curbing.
4. Planting of shrubs and bushes.
5. Signs.

Bryant Burkhard.

Pedestrian fence reduces number of crossing points for pedestrians.

6. Reflector buttons and floodlights (a flashing light does not give the operator sufficient measure of distance or lateral location).

The ear may be appealed to by rubber flaps, buttons, or roughened pavement which makes a noise when the tires go over it.

The sense of feeling may be appealed to by mushroom buttons or raised units in the middle of the road, which give slight bumps.

The island itself may be curved to guide the direction of travel of a car brushing against its side.

Since in every new design it is desirable to "overdesign," the following series of protective devices is suggested as a practical maximum:

1. Offset lanes so that front end of island is not directly in front of natural path of approaching vehicle.
2. Widen paint line.
3. Install rubber flaps.

Bryant Burkhard.

Loading and unloading of passengers is completely removed from vehicular paths by pedestrian fence and pedestrian underpass.

4. Install mushroom buttons.
5. Provide control grooves for wheels.
6. Plant in "last fair chance" area.
7. Erect signs.
8. Install reflector signs.
9. Install front-end floodlight and flashing beacon.
10. Install high sign or floodlight visible over tops of vehicles.

The location of each device must be determined on the basis of the approach speed of vehicles, and validated by field research with full-scale sample installations. As speed reaches a high level, island treatment becomes especially critical.

LOW ISLANDS SHOULD BE USED TO PROVIDE A SPACE FOR THE MOTORIST TO "RECOVER" AFTER HE HAS MADE A WRONG DECISION. It Is Unsound to Fail to Provide the Motorist with Adequate Facilities for Regaining Control in Emergencies.

Since it must be assumed that the motorist will commit errors, definite provision should be made for him when he finds himself in difficulty. If this

Courtesy Massachusetts Highway Department.

Paint lines help move traffic over to avoid end of medial divider.

is not done many serious accidents are certain to take place. The usual type of pavement should not cover the area reserved under the "doctrine of the last fair chance," since it would then be used regularly by traffic, and not held in readiness for an emergency. The low island with a mountable curb appears to be best suited for recovery purposes.

It has been only within the last ten years that steering geometry and springing of automobiles have become sufficiently perfected to permit the modern car to pass over low curbings at high rates of speed and at different angles without being thrown out of control. Because formerly cars were not capable of safe maneuvers under these circumstances, complete effectiveness of the islands was unattained. Under modern operating conditions,

however, islands may serve dual functions. The first is to channelize traffic movements. The second is to provide an area upon which the motorist may voluntarily drive in an emergency, rather than collide with vehicles coming in the same or the opposite direction, or stalled in the operating lane.

The ideal island would be wide enough to permit one lane of last-fair-chance usage and still contain a safe physical barrier to prevent the escaping vehicle being involved in an accident with oncoming traffic. Where property

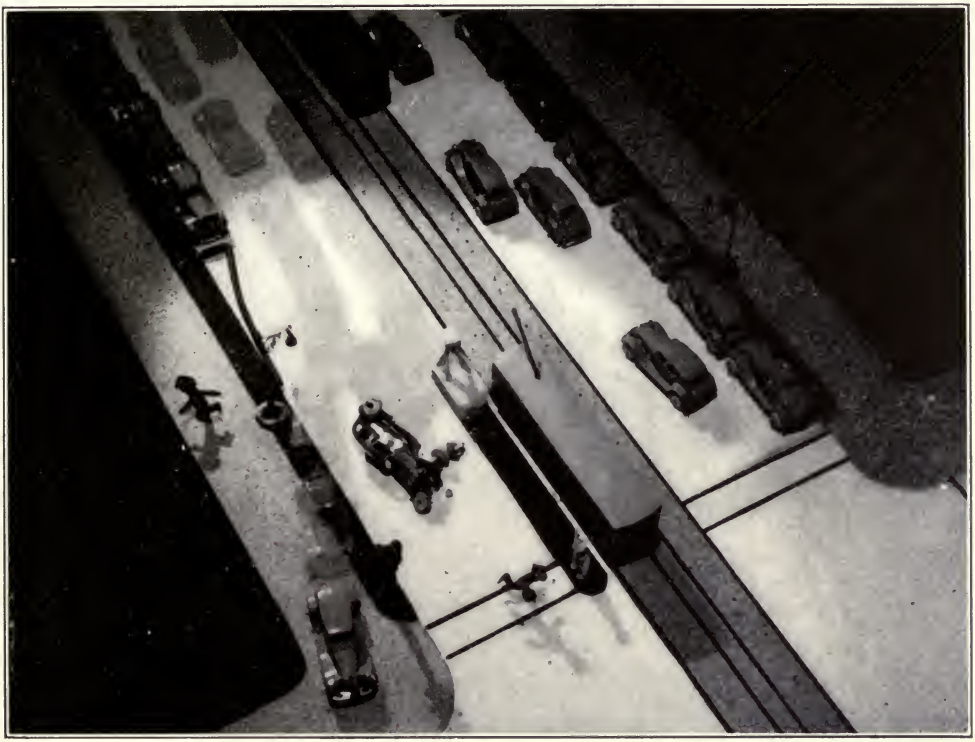
Bryant Burkhard.

Abrupt front end of island does nothing to streamline traffic lane movement.

value is high, an island of this sort would doubtless be less expensive than a 100-foot strip.

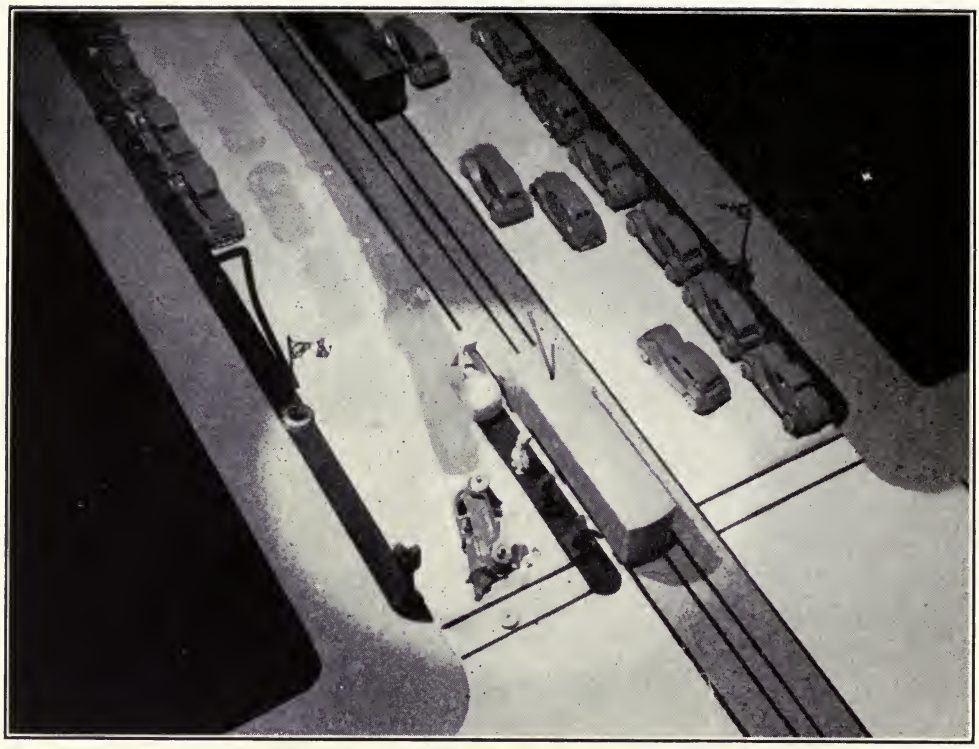
It must be taken into account that additional area alone cannot be relied upon to give the motorist a chance to escape in an emergency. This is because, if such space is available for travel, it will be filled with traffic, which will attempt to add an additional lane for movement. This means that whatever area is desirable for "recovery" must be blocked off and made unattractive in appearance and uncomfortable for travel so as to discourage its use for normal movement.

The low curbing which is easily mountable will, under some circumstances, serve an additional purpose in that, when located on the outside of a curve, it may provide just enough superelevation to save motorists who are approaching the curve at too high a rate of speed.



Bryant Burkhard.

Abrupt front end of island permits last-minute sharp, quick turn that may cause accident.

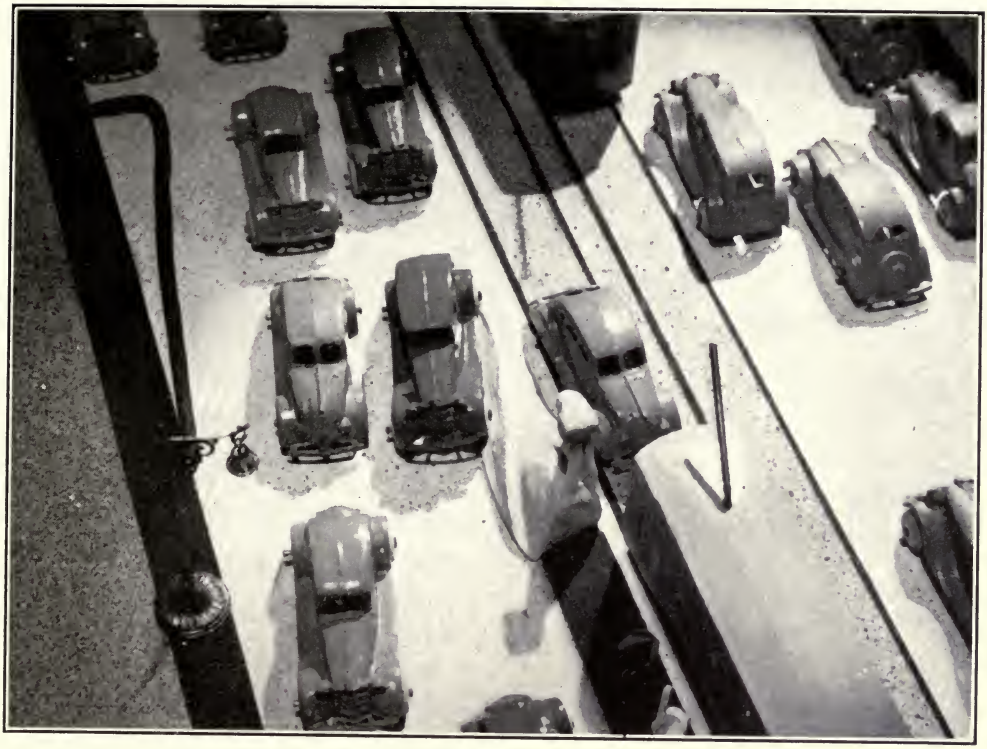


Bryant Burkhard.

Sharp edge of front end of island may overturn car.

Bryant Burkhard.

Front end of island, molded to fit easy, natural turn of motorist, aids smooth traffic movement.



Bryant Burkhard.

Car hits rounded front end of island and is eased back into proper position.

Courtesy United States Public Roads Administration.

Front end of island designed to slow down automobile by friction on under side of car and top of island prow.

CHAPTER XX

MECHANICAL CONTROL

The principles presented here cover the mechanical and electrical appurtenances of the facility which provide all control beyond that accomplished by geometric design. In a real sense they are as important to the facility as its materials and foundations. They should be considered integral with the facility and be provided as a natural part of its construction. The three major elements are signs, markings, and signals. Like every useful tool they have their limitations, and their misuse will cause great damage.

Traffic signs have reached a critical point in their development. Increased speed in rural areas will necessitate much larger signs. Increased advertising signs and general confusion in business districts will likewise make more effective signs necessary. The signs should be supported and augmented by additional markings.

Traffic signals are not a cure-all for accidents. They may increase accidents. They may cause much unnecessary delay and irritation. There is a definite demand for increased visibility and for more accurate timing to adjust signals to the traffic flow.

Signs and signals are essential under many present conditions. In some cases they are essential because of the failure of some functional element of geometric design, and they must remain in use until the fault is corrected. The utopia of design would be a facility which needed no mechanical control except informational signs. Under some conditions it may even be more economical to build a facility at a particular point which would require functional props or crutches than to go to the expense of building a facility which would need no mechanical control. On most urban streets with built-in functional liabilities mechanical control may always remain essential, because it would not prove economical to reconstruct all inefficient streets.

Thus these controls are useful and relatively inexpensive, but they do not represent the ultimate in effective control. Marked improvement will probably be produced only by functionally correct geometric street and highway design.

Principle 88

TRAFFIC SIGNS FOR HIGH-SPEED LOCATIONS SHOULD BE LARGER THAN 24 BY 24 INCHES AND SHOULD NOT BE PLACED WHERE MOTORISTS, STOPPING TO READ THEM, WILL BE IN A HAZARDOUS POSITION. Owing to the High Speed of Modern Traffic, the Size of Signs Has Become Doubly Important; But Increases in Size Have Not Kept Pace with Increases in Velocity.

The problem of traffic signs has become increasingly difficult as velocities have increased. Signs that were quite adequate for lower speeds are con-

Bryant Burkhard.

Supersized informational sign to slow traffic entering urban area.

stantly becoming less effective. A sign is of little value unless it can be read—in fact, some signs may be of negative value. To be of value, a sign must be readable at a distance far enough in advance to give the operator opportunity to alter his speed or direction in accordance with the condition described by the sign.

The manual entitled *Uniform Traffic Control Devices for Streets and*

Highways recommends signs 24 by 24 inches, to be increased in multiples of 6 inches as speed and traffic conditions warrant.

Where modern designs for speeds of 60, 70, and 80 miles an hour are anticipated, tests have shown that the lettering on signs must be from 12 to 16 inches in height. These figures are based on the assumption that the operator under these circumstances will need approximately 1000 feet of notice.

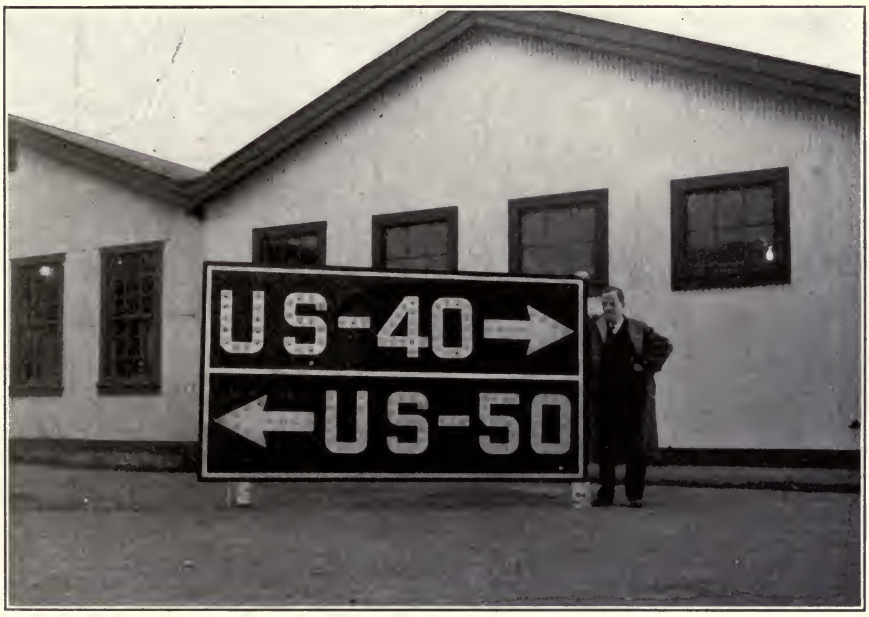
Bryant Burkhard.

Large advisory speed sign warns motorist of enforcement.

The vast increase in the size of this sign, compared to the old standard 24-inch sign, will bring with it additional problems. It may, for instance, be impossible to place oversize signs on existing shoulders. Again, hazards may be created if the sign reduces the sight distance.

Irrespective of the size of signs, particularly information signs, the motorist will often wish to stop and consider the situation. It is therefore important that the signs be located at a point where the motorist who stops to study them will not be in the direct lane of traffic movement, especially at the critical conflict zone of an intersection. A motorist who is on a cross-country trip not infrequently has a choice of routes. He may decide to

follow a particular route and to turn off at a junction ahead. Frequently this decision will not be conclusive. As he approaches the information sign at which the two routes fork, the sign will again bring up the issue which route he should take. If there are others in the car, a lengthy discussion may ensue. Directional signs located on the far side of a "Y" intersection will frequently cause the motorist to stop in the middle of the intersection where he has a good view of the sign. This is a point in favor of locating signs on the advance side of intersections.



Courtesy Nevada Highway Department.

Large route signs are a convenience and safety factor for high-speed roadways.

Elevation of supersized signs is often necessary so that they may be seen over the tops of intervening vehicles. The tendency on major four-lane highways will probably be to mount all signs over the operating lanes and to illuminate each sign.

Under some conditions, it may be worthwhile to erect signs on mast arms or span wires. The location of the sign in a direct line with the approaching lane which it is to govern might be most effective. On tangents most motorists tend to look directly ahead, and thus would be far more likely to see a sign placed in the line of vision than one 8 or 10 feet away from the pavement. If a four-lane highway is involved, this lateral distance would become 18 or 20 feet. On the other hand, the sign mounted over the highway would usually be at an elevation of 14 feet 6 inches. Since the driver's eye is approximately 5 feet from the pavement, this would give him a distance

from his normal glance of 9 feet 6 inches instead of approximately 18 or 20 feet.

The span-wire and the mast-arm mountings may cause difficulties with wind, snow, and ice. Under most circumstances, however, these handicaps very likely are of relatively minor importance.

It might again be well to mention the high public-relations value that supersized signs would have. A sign of such dimensions, location, and illumination as to be visible is an asset; but of infinitely greater value is

Courtesy Oklahoma Public Safety Department.

Trees can be used to add to target value of signs, create advantageous background, and block out competing advertising signs.

a sign with easy-to-read lettering. The satisfaction which legible signs give to the motorist is worthy of special attention.

It is important that large signs be attractive in appearance. Often they must compete with outdoor advertising signs or poster panels as well as with attractive surroundings. It is recommended that further study be given to the use of planting in connection with supersized signs, as roadside beautification may assist in focusing the driver's attention upon a sign. For example, a line of evergreen trees or shrubs ending in a sign would undoubtedly catch the eye of a driver. On the other hand, if planting is made without consideration of signs, the necessary target value of signs may be difficult to achieve.

Principle 89

TRAFFIC SIGNALS HAVE DEFINITE LIMITATIONS AND ARE MOST SUCCESSFUL IN REDUCING ACCIDENTS UNDER HEAVY VOLUMES OR HIGH SPEED AND OF A RIGHT-ANGLE OR PEDESTRIAN TYPE. Indiscriminate Use of Traffic Signals Must Be Avoided, for, if Signals Are Improperly Used, They May Increase Accidents and Delay as Well as Build up Resentment on the Part of the Motorist.

What Is the Traffic Signal? It is a device that removes the element of individual driver or pedestrian decision and judgment at points where performance records of accidents and congestion show that average persons in traffic are unable to get along by themselves. This is no criticism of drivers, because at many intersections there are too many factors for each driver to see and analyze without stopping or slowing to a point where his transportation will practically lose its value. Even then, because of his location in traffic, he cannot possibly see the over-all picture and decide what he should do for the benefit of others. Thus, the signal simplifies driving by telling the motorist when to go, stop or turn. It also tells the pedestrian when to stop and go as well as when he will have time to finish crossing the street.

The signal carries out this function more efficiently and cheaply than a police officer. Sometimes officers are needed to assist signals. Where left turns are heavy and a special period is not used or where pedestrians are frequent, a police officer is needed to assist the signal by opening gaps in traffic to permit certain movements to take place. In all cases, some enforcement is needed, although the obedience factor of signals is higher than that of all other traffic devices.

The right signal correctly timed is superior to the police officer largely because intersection control requires such frequent changes in direction that no human body can stand the strain of arm waving more than a few hours. The mental strain of having to watch at least four directions and make constant decisions as to when the direction of movement should be changed is too wearing to permit efficient operation for many hours.

One difficulty of the fixed time traffic signal is that it cannot efficiently stop traffic in one direction when there is no cross traffic approaching. This may be removed by the introduction of traffic-actuated mechanisms. Another difficulty is that, unless special turning arrows are installed, the left-turn movements will still require critical decisions upon the part of operators. Yet another difficulty is the fact that the pedestrian is still confronted with

a conflict from right- and left-turning vehicles. This may be reduced by means of traffic islands and, under extremely heavy pedestrian movement, by special pedestrian periods.

From the point of view of congestion, the traffic signal has definite limitations. On account of the intersection itself, it can permit only one stream of traffic to flow by the brutal process of shutting off the other stream. The essential yellow or clearance period may consume as much as 20 per cent of each cycle. Under normal conditions, the traffic signal should be operated on as short a cycle as possible in order to produce the least amount of unnecessary delay.

In general, traffic signals will be most effective where volumes are reasonably heavy. They are particularly valuable for reducing right-angle collisions as well as pedestrian accidents, but they are not so successful with turning accidents. Under conditions of extreme high speed, traffic signals can be effective if they are of the actuating type.

Traffic signals may be used effectively to control the speed of vehicles where adjacent intersections require signalization. This may be accomplished by establishing a flexible progressive system, timed to the desired speed. Motorists proceeding at a pace more rapid than this speed are discouraged by having to stop at each successive corner.

Traffic signals are dangerous if they are not visible. On open highways, the modern 8-inch lens under many circumstances does not have sufficient power to compete with the brightness of the sky or the greenness of the foliage. On downtown city streets, it does not have sufficient power to compete with advertising signs. Naturally efforts should be made to obtain reasonable control over advertising signs, but this will be a slow process. It is hence recommended that the light output of signals should be increased and that targets or artificial backgrounds should be provided to make them stand out.

Under most circumstances, it is probable that four far-right corner installations, extending as near as possible to the center of each controlled lane, will be most effective. If streets are wide, supplementary faces should be added at 180 degrees. If pedestrians are frequent, supplementary signals may be added at 90 degrees. On wide streets with streetcars, buses, and trucks, the four far-corner locations may be supplemented to advantage by a suspended four-face signal.

It is strongly recommended that national signal standards be adhered to.

Congestion and accidents started in cities where the bulk of traffic movement took place. Owing to heavy increases in volume and speed, the problem has backed up out of cities along state highways to a point where the state highway department is now faced with as serious a problem as the city and town. In addition, many cities and towns have expanded along the entering state highways so that the traffic problem on the highways, though still outside the city limits, is much more serious. This spread of accidents and congestion has made it necessary for the highway department to use many new tools which had previously been relatively unimportant as far as state highways were concerned. Very important among these new highway department tools is the traffic signal.

It is believed that every highway department will have a traffic engineering division. Every traffic engineering division will have a traffic signal engineer. Every state highway department will install, operate, and maintain traffic signals on its state highway system. The state must actually do this work, because it is on the state road and in many cases the new state highway has created the problem and the community cannot afford to put in the necessary control equipment. The most serious state highway problem today is to be found where state highways enter, leave, or are adjacent to built-up areas in cities or towns. It is quite likely that dollar-for-dollar money invested at such points will produce greater reduction in accidents and delay than at other locations.

Since state highway departments are now in the traffic signal control field, or will be shortly, attention is directed to the signal itself and its application to rural highway traffic conditions.

What Traffic Conditions Are Required for Successful Signal Operation? The purpose of installing traffic signals is to prevent or reduce accidents and congestion. If the signal does not reduce accidents or congestion, it represents a serious waste of money. If it makes things worse, it is even more costly. The problem is not so much when an intersection requires a signal, but rather, under existing traffic conditions at the intersection, what kind of signal will work efficiently. It may be stated that a signal could be installed at every important intersection without causing any harm if the most flexible equipment were used. But unless the reduction in accidents and/or delay exceeded the cost of the signal, it would not be a sound investment. The basic issue is primarily economic. Money must be spent to save losses but must not be spent if no losses can be saved. Hence a thorough engineering investigation must be made of each intersection under consideration.

Traffic conditions must be such that the type of signal selected can be timed so as to provide a minimum of unnecessary delay. If a signal causes much unnecessary delay, it will either result in disobedience by the motorist or pedestrian and will result in accidents, or it will cause public ill will which will reduce support for the traffic engineering department and ultimately reduce traffic budgets. The observance of signals which do not fit traffic conditions may be temporarily kept at a satisfactory level by very strong enforcement. But this is very expensive on the one hand and poor public relations on the other. The only ultimately satisfactory solution is to have traffic signals fit traffic conditions sufficiently well so that the minimum of delay that occurs is accepted as reasonable by motorists and pedestrians and they will automatically obey the signal indications.

Traffic conditions will determine the type of signal which must be used:

1. **Unlimited Traffic.** Heavy, equally distributed, consistent-volume intersections may be handled by the least flexible or fixed timer which can be changed by hand or time clock to flashing yellow or red and yellow when the volume drops off. Unlimited reservoirs of traffic make metering of movement by signals very simple, but such conditions seldom prevail for many hours on state highways.

2. **Variable Volume.** If the volume varies markedly, a more flexible fixed time signal and time clock should be used to keep the timing of the signal in step with traffic conditions.

3. **Unbalanced Ratio.** If the ratio of traffic at an intersection is heavily unbalanced, a still more flexible fixed time signal and time clock should be used or the unnecessary delay will cause serious difficulty.

4. **Frequently Changing Traffic Flow.** When intersection traffic varies from very heavy to very light, and the spacing of vehicles approaching the intersection is highly intermittent, or when the ratio of traffic (when light) is severe, an actuated signal must be used to make the necessary adjustments in timing automatically.

   (*a*) If the flow is distinctly unbalanced, a semi-actuated signal with detectors on the side street only may be used.

   (*b*) If the flow is balanced or reverses itself frequently, a full actuated signal with detectors on all entering streets may be used.

5. **Pedestrian Actuation.** Frequent pedestrian movement may require push buttons if the signal cycle is too long or if an actuated signal is not changed sufficiently frequently by vehicular movement.

It will be seen from the previous simple analysis that a careful study

of traffic movement makes it possible to determine what functional type of signal should be used at a given location. The amount of delay can be forecast. Obviously the more flexible the signal the less the delay. Since the more flexible equipment costs more, the time and accident reductions produced by more flexible equipment through reducing unnecessary delay must be enough to pay for the difference in cost; otherwise the investment is not sound.

No one functional type of signal will fit all types of traffic conditions most economically. They all should be used, but selected to fit the intersection. Allowances must be made for future traffic developments and a small stock of equipment kept to permit changes in timers at a later date when traffic conditions have changed. Consideration must also be given to the maintenance facilities if several different timers are to be used.

Is the Relative Cost of Traffic Signal Control High? The traffic signal is an essential tool of the traffic engineer. Well-designed intersections that have channelization with islands, rotary traffic circles, or grade separations, and that do not need traffic signals, are relatively few in number. Because of their cost, they can only be built slowly over a period of years. In some cases they may not be as economical as a functionally poorer intersection design augmented by traffic signal control. Thus, literally thousands of intersections, built before modern traffic requirements, require attention to reduce accidents and congestion. In a great many intersections the traffic signal, properly adjusted to traffic conditions, may be the most economical solution.

The cost of the traffic signal must be considered in terms of its proportion to the cost of the entire roadway, as well as the savings which the investment produces. With even as short a stretch as 5 to 10 miles of highway or a few blocks in the city the cost of signals could hardly be found in the total contract if they were installed at the time the roadway was built. Traffic signals are as important a part of the roadway as the pavement itself, when the roadway is thought of as a facility to move traffic rapidly and safely. It is understood that signals may be included for federal participation in new road construction costs in the same manner as guard rail is being included.

The cost of more flexible equipment must be thought of in proportion to the total cost of the installation as well as in terms of the additional savings in reducing accidents and congestion which it may produce. Such items of cost as signal heads, posts, current supply, some connections and maintenance are constants and may represent as much as one-third to one-half of the total cost. Thus the cost of more flexible timing equipment must be thought of in terms of the percentage of the total cost.

The choice of the functional type of signal by the highway department, varying from the cheapest and least flexible to the more flexible requiring additional funds, is exactly the same in principle as deciding upon the type of roadway, varying from the cheapest waterbound to the best concrete which requires additional funds. It must be remembered, however, that the cost of any type of signal is but a small fraction of the cost of even the poorest type of pavement.

The highway department desires to provide the best transportation facility that available funds will permit. Within fiscal limitations, the choice of signal should be determined by the conditions required to permit each type of signal to function satisfactorily and the amount of savings in accident and congestion reduction which each signal can produce.

Where speed, volume, conflicting movements, accidents, and delay are concerned, the signal contributes much more than the type or cost of pavement and at only a fraction of the cost.

The savings in accidents and reduction of congestion are very real and fundamental even though they are not collected on the spot and thus do not go immediately into the budget of the highway department. If highway departments are to provide faster and safer facilities, they must do this by proper traffic signals as well as by improved road design. Highway departments are accustomed to straightening out a curve or reducing a grade to provide faster, safer, and cheaper transportation. These represent relatively large capital expenditures, compared to signals. Thus, expenditures for signals should be considered from exactly the same point of view. The savings in either case are of the same nature and will serve the public, obtain public support, and pave the way for even better facilities in the future.

How Does the Rural Problem Differ from the Urban Problem? Traffic conditions on rural state highways have two characteristics which distinguish them from city conditions, namely, higher speed and lower volumes. These two conditions require very different treatment from the city problem of lower speed and heavier volumes: (1) higher speed requires much greater signal visibility, while (2) lower volumes require more flexible timing equipment.

It is logical to suppose that, if other traffic factors are relatively constant, accidents will increase or decrease as the opportunity to have accidents increases or decreases. This opportunity is customarily measured by traffic volume. Actually, to be more accurate, the volume should be refined to the volume of conflicting movements. This would give a fairly accurate picture of potential conflicts. One further refinement which could be made is the introduction of normal spacing in traffic flow and the conversion of this

to a probability curve. This principle would be fairly easy to establish by research.

Because the use of traffic signals on state highways outside of business and residential areas is relatively new, there are few research figures to assist in determining the best practice. The best that can be done at the present moment is to analyze the factors that are involved in an effort to establish adequate standards.

How Much Visibility Do Highway Traffic Signals Require? Scientific measurement is not needed to show that rural signals need higher visibility than what used to be an acceptable standard in cities (although it is necessary to show how much).

1. Drivers of vehicles traveling at 50 or 60 miles per hour must be able to see traffic signals much farther ahead than traffic moving at 25 miles or 30 miles per hour, if they are to have time to analyze the situation ahead, decide upon a course of action, and be able to put this course of action into effect before reaching the intersection. Many students of traffic, in approaching the problem of signs for high speed, believe that an attention-attracting distance of 1000 feet is essential. The Pennsylvania Turnpike is using signs that can be seen at distances of 800 to 1000 feet, and the reaction on the part of the motorist is very favorable. It is believed that highway signals should be visible for at least 1000 feet.

2. A natural error on the part of the driver at rural speeds is much more serious than at city speeds.

3. The frequent background of bright sky or green trees makes signals much more difficult to see, owing to lack of color contrast and competition of light.

4. The driver on the highway is much less likely to expect to find traffic signals in the country whereas he is used to finding them in cities.

5. The width of highway intersections tends to place the signal farther away from the driver.

In order to provide additional attracting value and visibility at highway signal locations, it is recommended that several special provisions be made:

1. That two signal faces be used for each approaching highway, rather than one. This increases the visibility of the installation by:

(*a*) Giving double the output and attention value.

(*b*) Providing two chances to see the indication, important if one is hidden by a bus or truck.

(*c*) Assures that the indication will always be there by providing

a safety factor in the event that one bulb burns out. It is extremely unlikely that both bulbs would burn out at the same time.

(*d*) By having two locations so that when the motorist has reached the stop line he may have one signal far enough ahead of him so that he will not have to throw his neck out of joint trying to find out when the green signal comes on and he may proceed.

This is superior to trying to get a larger signal assembly which, being non-standard, would cost more in addition to the fact that increased light concentration though helpful in the daytime might cause glare at night.

2. Placing one signal face directly over the approaching lane rather than over to the right behind the curb as in cities. This location is much more likely to be seen by the highway driver, who is usually looking straight down the road. This places the signal approximately 10 feet above the driver's eye but directly in front of him (signal height 14 feet 6 inches less height of driver's eye 4 feet 6 inches), whereas the signal back of a 10-foot shoulder is about 18 feet to the right of the driver's eye (10-foot shoulder plus driver's eye being approximately 8 feet from the outside edge of a 13-foot lane). If a four-lane pavement is considered, the lateral distance would be 31 feet for the driver in the passing lane (10-foot shoulder plus 13-foot lane plus 8-foot eye location).

3. Use of targets to create a suitable background for the signal itself. This follows current railway signal practice.

4. Painting of the signal housings and mounting posts federal yellow. This is especially valuable for contrast against a background of trees or bushes with leaves.

5. The use of advanced signals and/or warning signs at curves or hills to prepare the motorist well in advance for a possible stop.

6. The use of a stronger center line and stop lines and stop-line signs.

7. The output might be satisfactorily increased by using a higher-watt lamp, a tapped transformer, and a time clock. In no event should a bulb of less than 60 watts be used.

8. Since visibility is at a premium, good maintenance is also at a premium.

What Traffic Conditions Warrant Signals at Rural Highway Intersections? It may be assumed that highway intersections needing signalization will fall into the following general classes.

1. Outside business and residential areas.

(*a*) Light volume but need for speed control, with or without visibility restrictions.

(*b*) One heavy state highway intersection by a fairly light cross-road (town, county or state highway).

(*c*) Two fairly heavy state highways.

Bryant Burkhard.

Cross-walk painting is sometimes done under difficulties.

2. Inside business or residential areas such as the entrance of a state highway into:

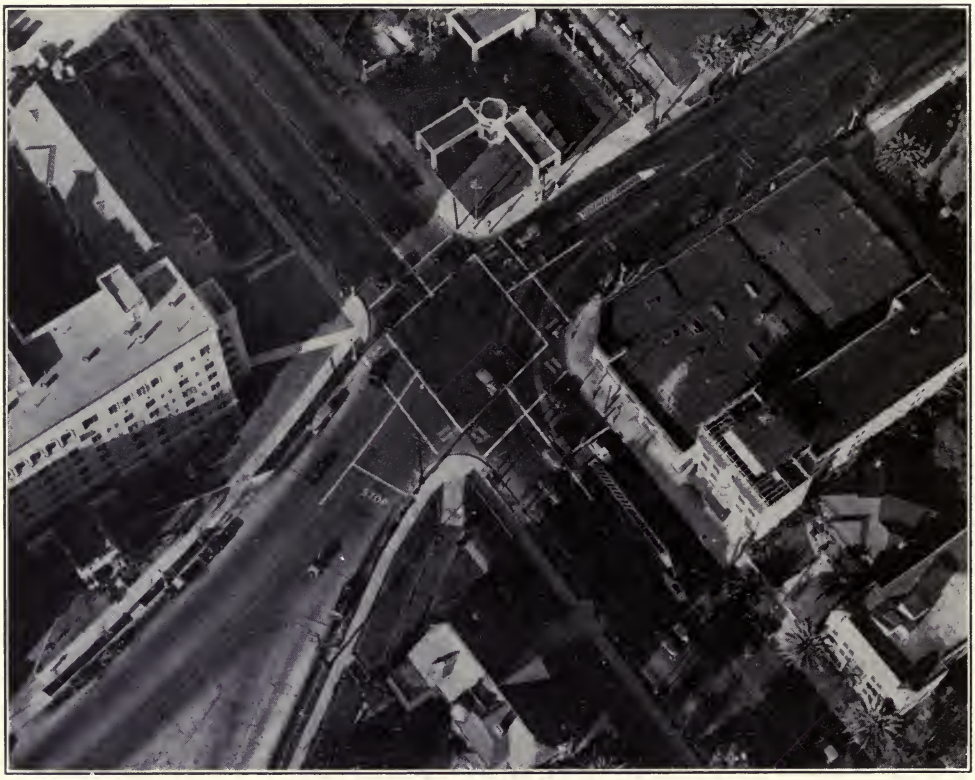
(*a*) Outskirts of a large city with changing speeds.

(*b*) Entrance into a small town.

(*c*) Location at strip development of business or a sub-business district outside city limits.

It is immediately noted that the most common problem is neither one of very heavy volumes and great congestion, nor of pedestrian control, although cases of both will be found. The most common basic problem is speed and safety as well as relieving the main streams from congestion and giving cross traffic a chance to cross.

The accident problem should naturally receive first attention. If an intersection has three or more accidents a year, there is no question but that



Dave Packwood.

Paint lines delineate center lines, crosswalks, stop lines, and loading zones.

it requires immediate attention. An analysis will clearly indicate whether the accidents are of the type which are amenable to signal treatment. Generally speaking, signals are most effective in reducing (*a*) right-angle crossing accidents (not left turns), and (*b*) accidents where speed is a prominent contributing factor. They also have a high degree of obedience.

Before resort to a traffic signal is made, the situation should be analyzed to see if signs (slow, stated speed, or stop) with increased size and illumination will do the job. Other choices such as removing obstructions to view

or channelization should be studied. If these alternative treatments have not been tried sufficiently elsewhere to gauge their effect upon the motorist they should be used as a first step toward the final treatment.

In many cases, especially at fairly new intersections, it is unwise to wait for the accidents to happen. A simple survey of safe approach speeds and the prevailing speed of approach may show the need of control before accidents begin to happen.

Bryant Burkhard.

Special pavement marking shows correct movement for left turn.

It is entirely possible that warrants for signalization based on approach speed, spacing, and probability of the simultaneous arrival of vehicles whose intended movements would conflict can be worked out scientifically.

Until exact measurements have been made, it is suggested that it might be good administrative practice to use a definite figure for approach speed in highway intersections as a yardstick similar to the use of volume as a yardstick at city intersections. This figure should probably be about 50 miles per hour for passenger cars during daylight hours. This speed should

be measured within approximately 500 feet of the intersection. The figure used might be the 85 percentile figure or the pace figure. This would mean that 15 or more per cent of the vehicles would be exceeding 45 miles per hour. Such a figure would control the total number of signals to be installed in the same way that volume figures do. Obviously, if a speed of 60 miles

Courtesy New York Public Works.

Paint lines can be used to simulate raised control islands.

per hour were used, very few signals would be installed on this warrant, whereas if 30 miles per hour were taken, too many signals would be installed in this warrant. Naturally different figures must be used for different sections of the country.

It should be pointed out that the volume warrants of 500 and 1000

vehicles per hour in earlier codes were originally selected by mere observation and in the complete absence of definitive measurements. It has subsequently been varied in many states, but it originally did and still does serve a very useful purpose. Originally the volume figure was used partially to require a traffic situation which could be handled efficiently by a fixed time signal. It was obvious that a low volume of 300 vehicles per hour with a cross street ratio of 20 to 80, giving 60 and 240 vehicles, requiring on the one hand a short cycle of about 40–50 seconds and on the other a ratio of

Courtesy Missouri Highway Department.

Large area needing channelization by islands is served temporarily by paint lines and signal mountings.

periods of 20–80, was impracticable since it would give 40 and 10 seconds (10 seconds being too short a time for vehicles to cross). Thus, either the total cycle would have to be raised to 60 or 70, which would delay traffic unnecessarily, or the periods would have to be set at a ratio not in accordance with the traffic flow, which also would cause unnecessary delay.

The reasoning on using speed as a safety (pre-accident) warrant is based on the fact that in the upper brackets of speed the driver does not have time to do his analyzing of the traffic situation and reach the correct conclusion frequently enough and is likely to commit frequent errors, which

at such speeds are exceedingly dangerous. Under these conditions the speed must either be slowed down or the traffic situation materially simplified by reducing the necessary decisions to a minimum. If the speed cannot be slowed down by signs or flashing beacons or the additional police manpower cannot be obtained or is too expensive, then a proper stop-go signal may be the best answer. The signal reduces the decision factor to merely obeying the indications and as a general rule reduces the speed because the operator is always afraid that the green signal will turn red, and he must slow down so that he will be able to stop in such an event.

Courtesy Nevada Highway Department.

Machine painting is constantly improving.

It is thus recommended that approach speeds be measured and that a speed warrant be established as one of the warrants for the installation of traffic signals at rural highway installations. This warrant must naturally be coupled with volume warrants to get a sufficient volume to give an exposure worth considering and to provide some time-savings to justify the cost of the equipment.

If a speed warrant were to be used, it probably should be set up under two classes:

1. **Restricted Sight Distance.** Here the speed warrant would be based on the number of miles per hour of the approach speed above the

safe approach speed. This assumes that, if drivers of vehicles are outdriving their sight distance, they are likely to have accidents. If stop signs are on the cross street, it assumes that some violations of the stop sign will occur, or that, after stopping, a cross-traffic vehicle would still have a hazardous time crossing high-speed traffic.

2. Unrestricted Sight Distance. Here the speed warrant would be entirely based on the inability of the driver to keep his car under control and maneuver through cross traffic above a certain speed. It should be pointed out that stop signs do not completely solve this problem. In many states, after the driver has stopped at the stop sign, he may legally proceed. The through traffic is reluctant to stop, and critical decisions are still required. These decisions do not seem to be made correctly at very high speed, and errors in judgment result in serious accidents.

Both conditions assume that the signal will tend to slow traffic down to a safe speed by the threat of having to stop.

Regardless of the accuracy of the speeds selected as warrants (and these should be established by research), the drawing of a line for speed will serve to prevent the installation of unnecessary signals just as the volume warrant has been effective in this regard.

Traffic signals are important to highway departments. Owing to high speeds and light volumes their successful operation may be more difficult than in cities. They do hold great potential values and should be studied very carefully.

MARKINGS ARE PAVEMENT SIGNS GENERALLY USED AS AUXILIARIES TO REGULAR SIGNS OR WHEREVER REGULAR SIGNS CANNOT BE PLACED.
Paint Lines on the Pavement Are Usually Employed to Advise the Motorist Regarding His Lateral Position on the Highway, to Keep Him from Crossing the Center Line at Dangerous Places, and to Tell Him Where to Stop at Stop Sign and Signal Locations.

The most common use of the paint line is to mark the center of the road. This advisory function is an important part of the highway. If a highway is worth paving it is worth painting.

Bryant Burkhard.

Lane treatment of complicated roadways by paint lines is effective.

The marking of "no-passing zones" is of very great importance. Every section of a two-lane highway where the sight distance is too short to permit safe passing at the posted speed (higher if this posted speed cannot be enforced) should be specifically marked. The average motorist, under pressure of the urge for mobility, has indicated that he cannot be relied upon

to judge the required sight distance. If the marking of these zones is undertaken, it should not be done sporadically. Complete units or the entire system should be marked. If some are marked and some are not, the motorist will be lulled into a trap in the secure feeling that all the zones are marked.

The marking of lanes on multi-lane highways is essential if the lanes are to be used efficiently. In many cases the pavement joint is not adequate. Even on two-lane highways, especially if they are substandard in width, it would be advantageous to place a paint line on the outside edge of the

Bryant Burkhard.

Wavy paint lines are sometimes used to attract the motorists' attention on approach to a center pier.

pavement as well as in the center. This proves especially beneficial at night, or during rain or light snow.

Markings to lead the motorist away from fixed hazards in the pavement are important.

Since motorists will instinctively follow alignment, longitudinal lines have a powerful effect in keeping cars from going off the road.

Stop lines and crosswalk lines should be placed at every traffic signal location where pedestrian movement warrants. If the intersection is sufficiently important to warrant a signal, it warrants a paint line.

Stop lines should be placed at stop sign installations whenever the sign

cannot be located at the precise spot where the motorist should stop. The actual stopping point of the motorist is important, for it may control the visibility of the stopped car to cars approaching on the through street.

Paint lines are one of the best advertisements of the traffic engineer. They should not be skimpy, and they should be kept freshly painted, for their sloppiness will be taken as typical of all the work of the department.

Principle 91

SPECIAL PROVISIONS MUST BE MADE FOR INCREASED NIGHT TRAVEL. Every Roadway Should Have Some Form of Illumination Aids.

Aids to visibility have demonstrated their economy through numerous studies. It is probable that almost every city would save money by investing additional funds in further aids to visibility. Some of these aids are

Courtesy Michigan Highway Department.

Reflecting units are valuable aids in delineating the roadway at night.

of great value to many other phases of organized security, such as prevention of crime and juvenile delinquency; they tend to increase business, and they induce a general feeling of greater safety on the part of citizens.

Irrespective of how good the design may be in the daytime, unless night visibility approaches day visibility in its aid to drivers, there will obviously be more accidents and more congestion. Hence aids to night visibility must

always be provided. The normal progression of these aids, in the order of their economic justification, will probably be as follows:

1. As light colored a pavement as possible.
2. White center lines, lane lines, and pavement edge lines.
3. White material curbings and abutments.
4. Reflecting signs.
5. Reflectors in curbings and on all abutments (alternate black striping for snow conditions).

Bryant Burkhard.

Reflecting units make route signs effective at night.

All the above are contingent upon good headlights. Presumably more light from headlights than we now have is necessary, as the majority of experts agree that more accidents are due to lack of illumination than to glare. But more illumination cannot be provided until motorists learn to use their upper and lower beams more safely.

6. Reflectors on posts to delineate the roadway.
7. Illumination of signs, abutments, islands, and curbings by electric lights.

8. Street lights at accident and congestion "hot spots," such as bad intersections, curves, hills, and pedestrian crossings in urban areas.

9. Street lights on all important city streets.

10. Street lights on all important trunk lines in metropolitan areas or on intercity routes.

The basic function of any form of illumination is to give the motorist the same essential traffic information at night as in daylight.

Courtesy United States Public Roads Administration.

Street lights make limited-way grade separation safer and pleasanter at night.

Care must be taken not to create optical illusions by the placement of illumination in such a way as to give an untrue picture of the situation.

Naturally, efforts at providing illumination should begin at places on the roadway where the greatest accident and congestion inefficiencies occur. There is a greater presumption in favor of providing street lighting on heavily traveled roadways because of the greater number of people who would benefit and the lowered cost per vehicle.

Although illumination is highly important, care must be taken not to spend funds for it in places where the return per dollar invested will not be so great as for some other traffic engineering improvement.

CHAPTER XXI

PEDESTRIANS

This chapter outlines the very important problem of the pedestrian. Pedestrians are particularly difficult to control because they are able to

Courtesy United States Public Roads Administration.

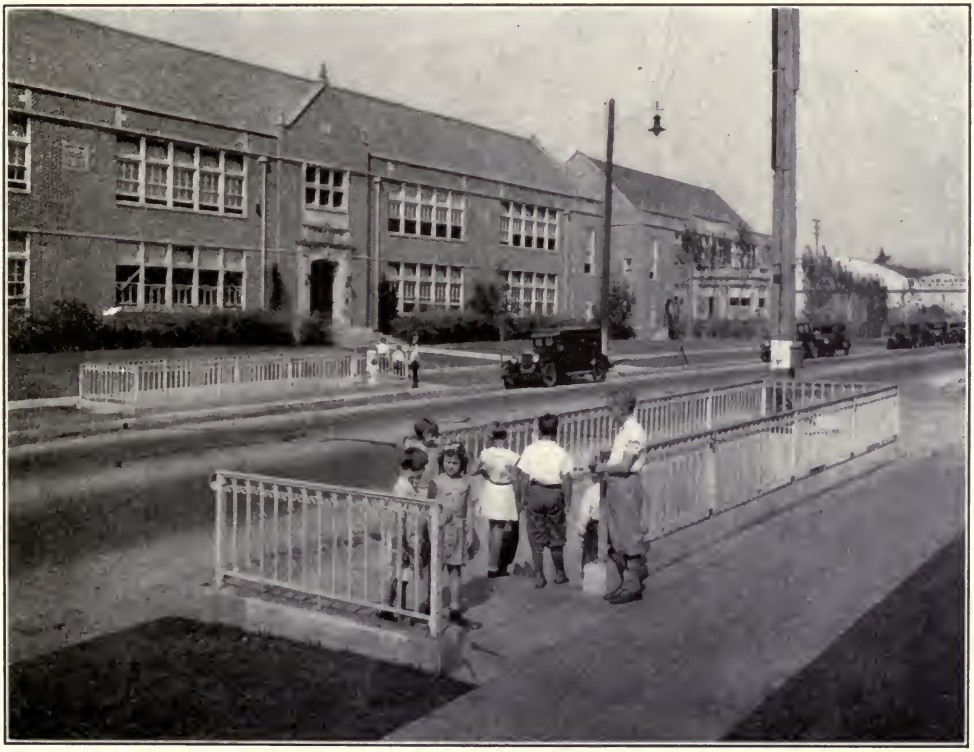
Pedestrian sidewalks in underpasses should be fenced off from vehicular traffic.

move in any direction without notice and they feel a right upon the roadway superior to that of the automobile.

The only sure way of controlling pedestrians is by physical structures which eliminate any choice. Tunnels, fences, bridges, sidewalks, and separate levels should be used wherever they may be economically justified.

THE MOVEMENT OF PEDESTRIANS SHOULD BE CONTROLLED BY PHYSICAL STRUCTURES WHEREVER POSSIBLE. Pedestrians Are Less Readily Controlled by Law and Enforcement Than Motorists. Pedestrian Fences Should Be Built Wherever They Do Not Interfere with the Loading and Unloading of Merchandise.

The pedestrian's right upon the roadway has usually been held superior to that of the motorist. The fact that he is much more vulnerable than the motorist has led the pedestrian to be particularly insistent upon this right.



Dave Packwood.

Pedestrian tunnels for school children are valuable if students are made to use them.

This has made the effective control of pedestrians difficult. Furthermore, the pedestrian, because of his universal direction of movement, can make more conflicting maneuvers than the average motorist.

In the long run the maximum amount of success in controlling pedestrians may be attained by establishing separate paths for the pedestrian,

underpasses and overpasses which place him on a different level from that of vehicular movement, and fences to keep him from impinging upon the natural paths of motorists.

In innumerable cases, after pedestrian subways and overpasses have been built, walkers have elected to cross at grade rather than go to the physical exertion of ascending and descending steps. Such structures, therefore, if they are to be effective, should be built only where the pedestrian may be fenced in and forced to use them.

It is probable that fences should be erected on numerous streets and highways where medial dividers are permissible and a minimum width of 2 feet is feasible. (Incidentally, an earlier use of the fence is found at most railroad stations.) It may be advisable to install fences back from the corner of intersections a sufficient distance to discourage pedestrians from "jaywalking." Certainly fences should be built at or close to the curb line on bridges or tunnels, adjacent to parks, or at any place where there is no legitimate or pressing reason for loading or unloading persons and merchandise.

There is little doubt that the utilization of fences for the entire length of loading and unloading pedestrian islands, so that the pedestrian will be forced to enter and leave the island at the crosswalk, is fundamentally sound, and it has proved satisfactory in many cities. In some cities the loading and unloading zone has been entirely surrounded by fence, with entrance and exit only through a pedestrian subway.

As has been indicated, traffic islands are one of the best means of assisting pedestrian movement. Channelization is an excellent process for controlling the movement of vehicles. Perhaps it would be equally effective to approach the control of the movement of pedestrians through channelization. If the paths of both can be channelized then exposure will be reduced and there will be less confusion as to where potential conflicts are to be located and how to look out for them.

PEDESTRIAN TUNNELS OR BRIDGES AND SEPARATE-LEVEL OR INSULATED SIDEWALKS SHOULD BE CONSTRUCTED WHEREVER HEAVY VOLUMES INDICATE ECONOMIC JUSTIFICATION. It Is Not Possible to Mix Heavy Pedestrian Volumes with Automobile Traffic without Numerous Accidents and Much Delay, nor Is It Possible to Mix Infrequent Pedestrians with High-Speed Traffic without Fatal Accidents.

At the intersection the differential in speed between the pedestrian at 2 or 3 miles an hour and the motorist at 15 or 20 miles an hour is too great to permit efficient traffic signal timing. Furthermore, unless right and left turns are prohibited, traffic is forced to fight its way through pedestrian lanes. This inefficiency over a period of years amounts to a tragic loss, both in accidents and in congestion.

A careful analysis of the situation would doubtless show economic justification for a large number of pedestrian tunnels and bridges and for separate-level sidewalks.

There seems to be a growing demand for pedestrian sidewalks in recreational areas, in industrial residence areas, or at the outskirts of cities. Sidewalks must have a surface equal or superior to the roadway itself if they are to be used.

It would be sound policy to require, under the zoning ordinances, that all new schools or large buildings immediately adjacent to important traffic thoroughfares provide either tunnels or subways. In heavy downtown central business districts these passageways could be incorporated into building structures. For commercial purposes the addition of escalators would be practicable; the added convenience during inclement weather and rush hours would justify the expense of this construction economically, from the business point of view.

Because of human limitations these new facilities for the pedestrian must not provide any noticeable inconvenience unless their utilization is forced by fences or barriers and their avoidance made less attractive than their use.

CHAPTER XXII

CONTROL BY RULE

Much can be done to increase the efficiency of the present street and highway system by rule. The two most common regulations are one-way streets and through ways or boulevard stop streets.

The one-way street can be used a great deal more than at present. It should be adopted on a large scale in cities as soon as its effect on business can be established. It will have increasing utility on adjacent parallel highways.

The arterial or through-way principle should be extended materially. Special roadways for special flows will prove more efficient than unlimited choice of routes by drivers.

The application of these two rules is relatively inexpensive and requires comparatively little enforcement.

ONE-WAY ROADWAYS SHOULD BE USED WHEREVER BALANCED PAIRS CAN BE FOUND, WHEREVER THE REDUCED TURNS DO NOT DETOUR OR INCREASE TRAVEL TOO MUCH, AND WHEREVER STREETS ARE TOO NARROW TO PERMIT PARKING ON EACH SIDE OR THE EFFECTIVE MOVEMENT OF FIRE APPARATUS. The One-Way Street Has Numerous Advantages over the Two-Way Street. It Completely Removes Medial Friction, Reduces the Number of Conflicting Movements at Each Corner, and Greatly Simplifies the Timing of a Flexible Progressive Traffic Signal System. It Increases the Capacity of Streets, Especially Narrow Ones, and Reduces Accidents.

There is good evidence for the statement that an increased application of one-way roadways would definitely increase capacity and reduce accidents. Frequently opposition has arisen in cities because some businesses feared they would be adversely affected. The solution to this situation is not the abandonment of the one-way street plan, but the taking of traffic and trade counts by which the relation of any traffic plan to business can be determined in advance.

It is also believed that one-way highways will be used more frequently in the future. The four- or six-lane divided highway is in reality two one-way streets, as is also the rotary traffic circle. Instead of widening a narrow two-lane highway into a four-lane highway, a process which too often necessitates the acquisition of costly lands and the moving back of buildings, the practical plan would be to construct a new roadway a quarter of a mile behind the existing buildings, or, if necessary, to purchase land at the rear of abutting farms. The old highway could be made one-way in one direction and the new highway one-way in the other. Farm traffic may be forced to use improved shoulders for short distances, but this may be worthwhile in the interest of the greatest good for the greatest number.

One-way streets may also be effective in leading traffic away from multi-street complex intersections where it is desired to reduce them to simple intersections. This same principle may be utilized to spread out an intersection and create what amounts to two separate intersections in order to reduce the number of simultaneous complications presented to the motorist.

The one-way principle may also be advantageous on streets which are too narrow to permit two-way movement and at the same time allow for parking or stopping on each side. On very narrow streets, one-way operation may be the only means of providing access for large fire apparatus.

The creation of permanent or temporary one-way streets is a helpful method of adjusting their capacity to an unbalanced peak flow which may develop during peak periods or on special occasions.

Caution should be exercised in making streets one-way which have more than two operating lanes. It is probable that three- and four-lane units are less efficient and increase the hazard. Under these circumstances consideration should be given to the introduction of traffic lane islands to maintain the desirable two-lane unit.

THROUGH-WAYS OR STOP-STREETS ARE OF VALUE IN INCREASING THE CAPACITY AND SAFETY OF MAIN ARTERIES AND IN ADJUSTING THE SIGHT DISTANCE AT BLIND CORNERS. It Is Sound Policy to Attract Through-Movements to a Small Percentage of the Streets or Highways and to Provide These Streets with the Best Possible Design and Maximum Control Devices.

The stop sign prevents uncontrolled interruptions of the main traffic and increases the safe approach speed of the main traffic by forcing cross-traffic vehicles to stop at a point where they are visible at greater distances to approaching traffic in the main street. At an isolated blind corner the safe approach speed may be increased on one street by placing stop signs on the other. Since it is almost impossible to enforce speeds below 15 or 20 miles per hour, it is better to stop the traffic on one street and on the other street permit a speed consistent with the increased sight distance.

The through-way or stop-street effectively protects major traffic flows from minor ones and increases the sight distance on two approaches to an intersection by stopping traffic on the two opposing approaches. Stop-streets or through-ways are exceedingly valuable for concentrating important through traffic.

It has been found that through-ways have a tendency to increase speeds, which in turn, in the presence of heavy pedestrian traffic, increase the hazard. A compromise must be reached. If the pedestrian problem is severe, through-ways are not a satisfactory answer to the problem, and traffic signals might be more effective.

Since the through-way causes inconvenience to those vehicles which are required to stop, it cannot be used successfully if a series of through-ways are close to one another.

Stop signs will not be effective when traffic is heavy because they create the debatable question of whether the second, third, fourth, and fifth cars should stop twice, or whether a car at the tail of the platoon is justified in proceeding through without stopping once the through traffic has been blocked aside.

Distribution of Traffic on Different Streets. The efficient utilization of present city streets may be increased considerably by providing some additional classification. In some cases certain streets might be set aside for heavy commercial traffic, and other streets closed to it. Streetcar and bus routes might be changed to provide some streets primarily for transit operations and others primarily for vehicular traffic. Residential, school,

and recreational streets might be blocked off or made one-way for alternate sections to prevent through-traffic where other through-streets are available. The through-streets themselves could be considerably increased in efficiency through protection by traffic signals and insulation by outbound one-way streets and the blocking off of unimportant light-volume non-through streets.

PART FIVE

HOW TO ATTACK THE PROBLEM

CHAPTER XXIII

THE APPROACH TO THE PROBLEM

An organized attack carefully planned in advance is the only way to obtain lasting progress. Tools and elements, organization and administration, public relations and financing, methods and procedures, and the selection and training of man power may be important. But to a very large degree their utility will be measured ultimately by the soundness of the plan.

All effective work hinges on selection of what to do with what is at hand. A balanced program must be welded into a plan. Each unit to be attacked must have a plan.

Even plans will not succeed if they are static. They will remain static unless research is conducted as a part of the basic plan to make plans better.

The following group of points is aimed at the method of the attack.

Principle 96

PROBLEM INTERSECTIONS SHOULD BE ATTACKED BY A DEFINITE PROCEDURE. It Is Essential that a Specific Formula or Process Be Developed for Attacking Problem Intersections or Locations. Consistency in This Procedure Will Increase the Efficiency of Route Operations.

Following are the steps and sequences considered most efficient in solving a problem intersection:

1. The essential traffic facts such as volume, speed and obstruction, origin and destination, economic evaluation, and forecast of future load, must be determined.

Kaufman-Fabry.

Large open area before channelization shows wide distribution of paths of vehicles with little control.

2. The existing conflicting movements must be carefully analyzed and charted.

3. The angles of convergence, divergence, and intersection must be measured.

4. The accidents must be studied and reduced to a collision diagram.

5. The physical aspects of sight distance must be measured and reduced to a condition diagram.

6. The roadway functional analysis of the entering streets must be made to determine their part in the design.

7. The possible remedial measures must be analyzed and evaluated.

(*a*) Consideration must be given to reducing the number of entering roadways: (1) by shutting off streets; (2) by creating one-way

Kaufman-Fabry.

Same intersection with channelizing islands shows much more orderly movement.

streets away from intersections, subdividing the intersection into two separate spaced intersections.

(*b*) Preference should be given to the major streets, assigning any unavoidable inconvenience to the minor streets.

(*c*) A count should be made of the number of potential conflicting movements which can be removed.

(*d*) Proposed islands should be analyzed to determine how closely they coincide with the natural paths of movement.

(*e*) The new or proposed sight distances should be measured and reduced to safe-approach-speed figures.

(*f*) All lateral transitions should be measured to ascertain whether or not they conform with the standards.

(*g*) All mechanical control devices should be checked for their effective installation.

8. Accident expectancy should be estimated. In many instances engineers should be willing to say, "Yes, we know there will be accidents at this new intersection because we did not have sufficient funds to make the intersection completely accident-proof. We were forced to retain some conflicts which, through the volume of traffic during the year, will make operative the theory of probability as applied to human error. But not enough accidents will happen to warrant further expenditures at this time."

9. Where practicable, all the above work should be completed before any traffic is permitted to enter the intersection.

10. The new intersection should be widely publicized before it is opened.

11. Arrangements must be made with officials so that sound enforcement may begin at the moment the intersection is opened for travel. (This assumes that there are some control devices or speed restrictions.)

12. Arrangements must be made to complete the continuation of the essential traffic data described in step 1, and subsequent accident and delay studies must be conducted to provide proof of the efficacy of the changes.

Principle 97

THE INTERSECTION PROBLEM MUST BE FACTORED. It Must Be Broken down into Its Basic Elements and These in Turn Must Be Molded to Fit the Fundamental Principles Which Control Successful Design.

The following steps are recommended in attacking an intersection which is to be redesigned.

1. The essential traffic data must be obtained.

Bryant Burkhard.

Headlight patterns show irregular, inefficient movement at grade crossing during construction of underpass.

2. The relative value of the intersection must be measured.

3. The different methods of improving the situation should be studied and reduced to a cost figure.

4. The plan decided upon should be carefully studied in terms of the number of conflicts and the amount of time which it will save, and the accidents which it will reduce.

5. The effect upon the origin and destination of traffic at the corner must be considered.

6. If the intersection is an important one and the expenditure large, it would be advisable to build a model of the proposed design.

Bryant Burkhard.

At same intersection the steady travel of lights from cars going through completed underpass shows increase in efficiency of movement.

7. Several different applications of the principles involved should be made either in rough draft form or in adjustment of the model.

8. Temporary islands might be installed if channelization is indicated.

Principle 98

THE ACTUAL PATTERN OF THE FLOW OF TRAFFIC SHOULD BE MEASURED PRIOR TO AND AFTER ANY CHANGE. This Is the Best Method of Measuring the Immediate Effect of Design Elements.

The commonly used methods of measuring the pattern of vehicular movement are by snow, sand, oil, and dust patterns, and headlight and taillight patterns shown by night photography using time exposure.

Bryant Burkhard.

Weaving conflicts are indicated by headlight patterns.

The existing pattern of traffic flow upon a particular roadway is one of the best tests of its difficulties. Until this has been worked out, little progress can be made. It is almost impossible to visualize the infinite number of traffic movements which take place. Samples of these must therefore be obtained.

The older methods of measuring the patterns of traffic movement were to study oil, snow, dust, sand, or flour patterns. A recently developed

technique makes it possible to measure these patterns more effectively and conveniently by means of photographs. It has been found that, if the opening of the camera is stopped at its widest exposure, night pictures can be taken from 4:00 o'clock on in the winter, for lengths of time running from

Bryant Burkhard.

Night pattern shows stops and starts and irregularity of movement.

30 seconds to 15 minutes. If colored film is used, the tail-light as well as the headlight patterns will be produced. This modern method is invaluable to the traffic engineer, not only because of the technical values which it possesses, but also because of the strong sales qualities which it has been found to have when shown to superiors, legislators, or the public.

ESSENTIAL TRAFFIC DATA MUST BE OBTAINED.
Traffic Improvements Cannot Be Made upon a Basis of Guesswork, but Must Be Founded on Accurate Information.

The following information must be available to serve as a foundation for traffic improvements:

Traffic Volume. This shows the present traffic pattern of vehicular and pedestrian movement and provides the quantitative measurement of each location. It is the most useful of the data obtainable and must be secured for all roadways and intersections having any accident or delay value.

Courtesy Oregon State Highway Department.

Motorists being questioned for traffic information.

Classification. This is usually included in most volume counts. It indicates the types of loads which the roadway must carry and determines the speed differentials, turning radii, and structural requirements.

Origin and Destination. The volume count shows where traffic is moving at the present time. This is not a positive index of where it desires to move because there may not be direct routes, because some routes may be more crowded than others, or because some routes may not be adequately marked or known. For this reason the origin and destination, or the intent, of traffic is of basic importance. It shows not what motorists are doing but what they want to do. This count has been sorely neglected in the past,

primarily because the technicalities of working it out are difficult. Only recently have state highway departments obtained comprehensive data, and few data are yet available in most cities. Although the origin and destination count goes deeper than the volume count, it still is not the final fact as far as future development is concerned. Population and registration changes, business and residential shifts, and recreational developments will change the origin and destination of traffic and thus the traffic pattern as

Courtesy Oregon State Highway Department.

The "electric eye" automatically counts traffic.

shown by the volume count. All these counts will be changed by traffic improvements. Thus a base count must be made first and kept up to date by short counts whose foundation or base must be verified about every three years.

Speed and Delay. The end product of any transportation system is the amount of time it saves over the older facilities. Nothing else is of equal importance from the point of view of the transportation engineer. In this sense the speed and delay count is the most fundamental of all. The volume

count tells how many units are affected, the classifications count what kind of units, the origin and destination count how many units are being supplied with the most effective route, but the final answer for the system is, how long did it take them to get there? This count too has been neglected. There are virtually no data as to the time-saving service which roadways provide. The average speed will give the time-service measurement, and the delays will isolate and classify the bad spots.

Courtesy Oregon State Highway Department.

Truck weights must be checked at many locations.

Economic. These studies are for the purpose of evaluating the worth of traffic facilities to individuals and to business. Unless all traffic activities can be reduced to a common denominator no adequate comparisons can be made. All traffic facilities must eventually be evaluated upon the basis of their effect on the motorist and on business. Practically nothing has been done to measure the business effect of traffic improvements before a proposed change is made. The engineer must make more economic counts in the

future, because his power of transportation betterment or retardation can often make or break business.

Accident Analysis. This important study must be made to determine the relative inefficiency of any roadway. One difficulty in the past has been accident reports designed primarily to serve the police and the motor-vehicle departments. Strenuous efforts must be made by engineers to see that essential engineering information is entered in accident reports and that an engineering summary is made of them which will classify accidents in terms of the remedial measures which the engineer has at his disposal.

General. Broad studies should also be made of topography, natural resources, population movement, commercial recreation, land use, and other basic elements necessary for sound planning.

Unless a traffic engineering department has these basic survey data on all its facilities at its fingertips in maps, charts, curves, and tables, it is in no position to make sound recommendations for improvement. This may seem a large order, but without these facts it has frequently happened that well-meant remedial measures, possibly brought about through pressure, have done more harm than good.

Specialized Counts. In addition to the essential base material listed, numerous special counts are required when particular devices or designs are applied. These must be worked out individually to a point where there are no unknown fundamentals.

The highway planning surveys carried on by highway departments in cooperation with the Public Roads Administration have made an excellent start on the collection of these data. It is hoped that their work will be expanded and extended into a greater number of urban areas.

CHAPTER XXIV

PUTTING THE PROGRAM TO WORK

Principle 100

PROGRESS CAN BE MADE ONLY IF ALL NEW DEVELOPMENTS ARE MEASURED. Logic Leads to Theory Which in Turn Leads to Specific Principles. But in Each Case Principles and Theories Must Be Validated by Actual Measurement.

Considerable effort has been spent in analyzing traffic problems and working out solutions, but far too little effort has been devoted to measuring the relative effectiveness of these solutions.

This practice has produced various difficulties. For instance, it has been difficult to discover the relative value of developments in different sections of the country. Thus there have resulted innumerable duplications. Again, it has not been possible for the traffic administrator to prove the value of those things which he believes to be sound or to build up sufficient support for their extension.

There is a growing need for before-and-after studies to put on record the scientific achievements in the field of traffic control. These studies should eventually be reduced to an economic basis upon which the justification of future capital expenditures for traffic improvements may be evaluated.

EACH STATE HIGHWAY DEPARTMENT SHOULD HAVE A TRAFFIC PROVING GROUND. Fundamental Improvements in Traffic Control Cannot Be Produced without Research and New Ideas Cannot Be Tried out on Public Highways without the Danger of Accidents and Unfavorable Public Reactions. Research Data Can Best Be Obtained under Completely Controlled Situations.

A traffic proving ground should provide satisfactory facilities and scientific equipment suitable for the conduct of tests of drivers, motor vehicles, roadways, and traffic and safety devices under controlled conditions.

Values of Proving Ground. The following are among important reasons why each highway department should establish its own traffic proving ground:

1. A traffic proving ground provides a laboratory for research. In the absence of research, little progress has been made in any field of endeavor. The automotive industry is an excellent example of the effects of research.

2. A traffic proving ground would make possible research under controlled conditions. Successful research cannot be conducted except under proper controls. Such conditions cannot be obtained upon public thoroughfares.

3. The conduct of fundamental traffic research upon public thoroughfares is unsound because of the continual hazard of accidents as well as the bad public reaction which such mishaps produce. Research conducted under these circumstances probably does not give conclusive answers. Many good designs have been discarded because of their failure on the public highway without previous tests. If these designs had been properly tested and minor adjustments made, they might have worked satisfactorily on the highway.

4. It is probable that numerous sound ideas developed by personnel of highway departments die because there is no opportunity for trying them out. The establishment of a proving ground would encourage constructive thinking in highway departments.

5. A proving ground would stimulate public interest, and this would be reflected in improved public relations.

6. Road materials have been tested for years by highway departments, and each year hundreds of thousands of dollars are spent in materials-testing laboratories. The operation aspect of highway administration is as important as the materials aspect, and thus there is justification for spending as much, if not more, money for testing traffic control methods.

Sample Tests. The following are some of the types of tests which could be carried out effectively on a traffic proving ground:

1. Natural paths of drivers.
2. Traffic-island design.
3. Curb design.
4. Signs.
5. Signals.
6. Markings.
7. Illumination.
8. New intersection design.
9. Guard rails.

Sample Desirable Elements of a Traffic Proving Ground. The following elements may well be included in a complete traffic proving ground:

1. Typical pavements (widths, testers).
2. Typical intersections.
3. Typical grades.
4. Typical curves.
5. Typical sight distances.
6. Straightaways to accommodate the higher ranges of speed—75 miles per hour and over.
7. Shoulders.
8. Ditches.
9. Convenient and strategic location. For example, a proving ground situated near a business area or heavy traffic stream would permit normal traffic to be diverted so as to pass through the proving ground when mass tests are desirable.
10. Equipment (housing, traffic devices, etc.).

A Modest Start Can Be Made. The establishment of the principle of a traffic proving ground is more important than the elaborateness of a plan. Almost any highway department may make a beginning by selecting a piece of abandoned right-of-way, or it may be possible, by the acquisition of a little land, to make certain extension of existing materials-testing laboratories. Over a ten-year period, these small developments should produce an effective operating laboratory.

Principle 102

A BALANCED PROGRAM MUST BE PREPARED. It is Especially Important that a Comprehensive Long-Range Program Be Developed and Scheduled.

The following is a suggested process for preparing a balanced program:

1. A survey of the present status of all traffic engineering activities.
2. Finding out what is not known.
3. Establishment of priority for projects.
4. Creation of warrants for projects.
5. Development of time-saving routines.
6. Preparation of codes.
7. Conduct of research.

One of the commonest difficulties to be found in public work is the constant pressure of routine assignments. Every administrator has so many demands upon his time from day-to-day tasks that it is difficult for him to reserve time in which to work out better ways of accomplishing his work. Hence the subject of a program should be assigned to one person with instructions to follow through. Once developed, the program should be reduced to a printed statement and a work schedule for it prepared. Monthly reports should be issued covering the progress of the units established under the program.

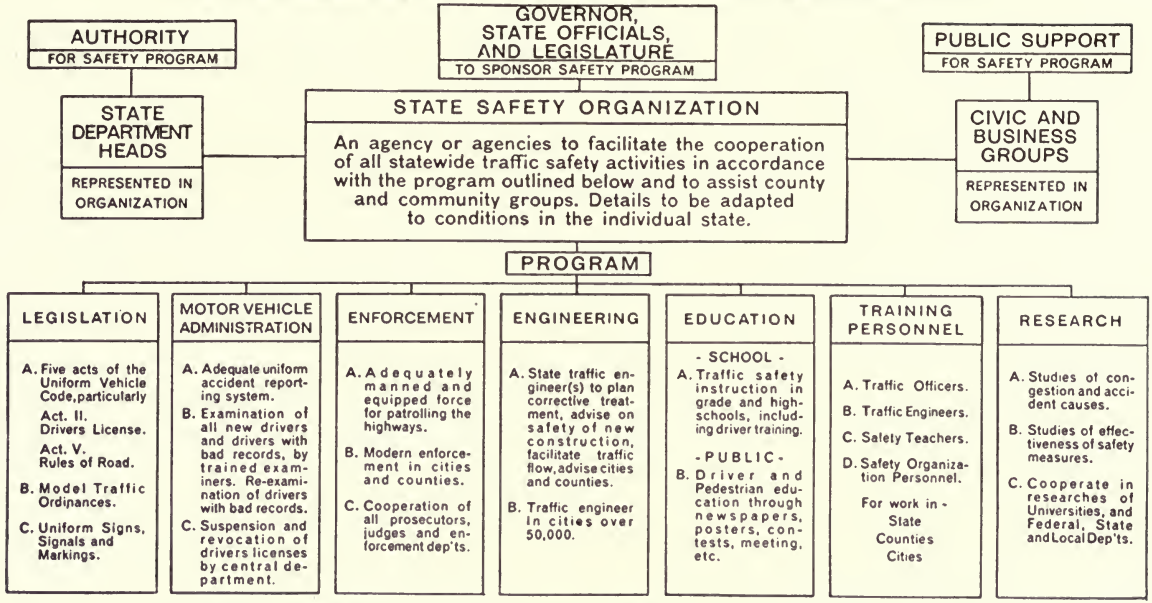
Without a check list, the multiplicity of operations will make it almost impossible for an administrator to have accurate knowledge of how things are going.

The balanced program should be fitted into a master program covering all the approaches to the automotive transportation problem. After a quarter of a century of development and testing there has resulted a "Standard Highway Safety Program for States." This is supported by national organizations with total membership exceeding 12,000,000. The Automotive Safety Foundation has been largely responsible for its instrumentation. The adoption of this program throughout the country will do much to reduce accidents and congestion.

STANDARD HIGHWAY SAFETY PROGRAM FOR STATES

TO INCREASE TRAFFIC EFFICIENCY AND REDUCE ACCIDENTS

Proven by the Experience of States which have reduced Accidents, and recommended by the Organizations listed below.


AUTHORITY
FOR SAFETY PROGRAM
GOVERNOR, STATE OFFICIALS, AND LEGISLATURE
TO SPONSOR SAFETY PROGRAM
PUBLIC SUPPORT
FOR SAFETY PROGRAM
STATE DEPARTMENT HEADS
REPRESENTED IN ORGANIZATION
STATE SAFETY ORGANIZATION
An agency or agencies to facilitate the cooperation of all statewide traffic safety activities in accordance with the program outlined below and to assist county and community groups. Details to be adapted to conditions in the individual state.
CIVIC AND BUSINESS GROUPS
REPRESENTED IN ORGANIZATION
PROGRAM
LEGISLATION
A. Five acts of the Uniform Vehicle Code, particularly
Act. II. Drivers License.
Act. V. Rules of Road.
B. Model Traffic Ordinances.
C. Uniform Signs, Signals and Markings.
MOTOR VEHICLE ADMINISTRATION
A. Adequate uniform accident reporting system.
B. Examination of all new drivers and drivers with bad records, by trained examiners. Re-examination of drivers with bad records.
C. Suspension and revocation of drivers licenses by central department.
ENFORCEMENT
A. Adequately manned and equipped force for patrolling the highways.
B. Modern enforcement in cities and counties.
C. Cooperation of all prosecutors, judges and enforcement dep'ts.
ENGINEERING
A. State traffic engineer(s) to plan corrective treatment, advise on safety of new construction, facilitate traffic flow, advise cities and counties.
B. Traffic engineer in cities over 50,000.
EDUCATION
- SCHOOL -
A. Traffic safety instruction in grade and high-schools, including driver training.
- PUBLIC -
B. Driver and Pedestrian education through newspapers, posters, contests, meeting, etc.
TRAINING PERSONNEL
A. Traffic Officers.
B. Traffic Engineers.
C. Safety Teachers.
D. Safety Organization Personnel.
For work in -
State
Counties
Cities
RESEARCH
A. Studies of congestion and accident causes.
B. Studies of effectiveness of safety measures.
C. Cooperate in researches of Universities, and Federal, State and Local Dep'ts.

THIS PROGRAM RECOMMENDED BY THE FOLLOWING ORGANIZATIONS

American Assn. of Motor Vehicle Administrators
American Automobile Association
American Institute of Steel Construction
American Legion
American Road Builders' Association
American Transit Association
American Trucking Associations, Inc.
Associated Business Papers, Inc.
Associated Farm Papers
Associated General Contractors of America, Inc.
Association of American Railroads
Automobile Manufacturers Association
Automotive Parts and Equipment Manufacturers
Automotive Safety Foundation
Benevolent and Protective Order of Elks
Better Vision Institute
Boy Scouts of America
C.I.T. Safety Foundation
Cycle Trades of America, Inc.
Electric Institute
General Federation of Women's Clubs
Highway Education Board
Independent Petroleum Assn. of America
International Association of Chiefs of Police
Kiwanis International
National Association of Manufacturers
National Automobile Dealers Association
National Congress of Parents and Teachers
National Conservation Bureau
Nat'l Council of Private Motor Truck Owners
National Electrical Manufacturers Association
National Grange
National Industrial Traffic League
National Institute of Manufacturers and Distributors
National Paint, Varnish and Lacquer Association
National Paving Brick Association
National Petroleum Association
National Safety Council
National Slag Association
National Standard Parts Association
Northeastern Retail Lumbermen's Association
Northwestern University
Portland Cement Association
Rubber Manufacturers Association
U. S. Conference of Mayors
Yale Bureau for Street Traffic Research

Courtesy Automotive Safety Foundation.

8887

HOW TO GET THE MOST OUT OF THE PRESENT SYSTEM. While Constant Efforts Must Be Expended to Render New Construction Functionally Superior, It Is Important that the Present System Be Utilized to Its Fullest Efficiency.

Much can be done to increase the utility of the present street and highway system. It is important that these be studied carefully, for often a greater return can be obtained from the existing investment than by reconstruction on a large scale. The following are of special interest:

1. Staggering of business hours to level off peak periods.
2. Intra-city routes to prevent unintentional wandering of drivers on heavy streets which they should not use in getting to their destinations.
3. Circumferential routes to reduce travel on downtown streets.
4. Bypasses to remove through traffic from downtown streets.
5. Industrial employer-employee assistance in the preselection of automobile commutation routes and selection of truck routes.

SUMMARY

It seems desirable to present a brief summary at this point. Twenty points have been selected to create a pattern for the reader to keep in mind as he proceeds throughout the text. When these points are accepted, the rest of the material will be found to fit together into a related unit.

The following points are worthy of emphasis through summary statement:

1. Automotive transportation is the real problem; accidents and congestion which occur in its operation are merely indices of inefficiency.

2. Federal, state, county, and city agencies of government have a definite responsibility to provide acceptable streets and highways. Present roadways lag behind the transportation potentials of both the automobile and the driver.

3. The attack upon the problem includes ten major methods.

4. Ultimately three-quarters of the transportation problem is up to the engineer. Education and enforcement as applied to the driver can reduce accidents by only about 50 per cent in the long run. This leaves the other 50 per cent of accidents due to natural human error up to the engineer, in addition to the entire other half of the problem, namely, congestion.

5. Signs, signals, and markings are primarily "crutches" to compensate for functional errors of design. Under some conditions, these must be retained for economic reasons. Future improvements of any real magnitude must come from basic changes in the functional elements of design.

6. All traffic losses and gains must be reduced to an economic formula in order to determine what capital investments can be economically justified for new facilities having superior functional design elements, and to establish which designs will give the greatest unit of movement service per dollar invested.

7. Highway departments must develop effective public-relations programs to convince those who pay motor vehicle taxes of the soundness of highway expenditures and to obtain the additional public support needed for future developments.

8. Separate traffic engineering divisions with separate traffic budgets

must be established in all highway departments and city engineering departments if an efficient attack is to be made upon the traffic problem.

9. Engineering divisions must adopt a sound training program for those men who are to take a leading part in this new field of traffic engineering, or "operations."

10. Highway engineering must be adjusted to the average driver, who will always commit errors. Design must become more and more automatic and eliminate the possibility of errors by reducing critical decisions, making many dangerous driving acts impossible, and making the right act the easiest and most natural. The driver has certain natural limitations with regard to reaction time, power of observation, and judgment. These are reduced by such elements as fatigue and distraction. Roadway design must be based on the residual abilities of the human machine, which become increasingly strained as speeds increase.

11. Highway departments have successfully met two specific stages of development, namely construction and maintenance. Theirs has been a brilliant achievement in constructing a three-million-mile system of streets and highways since the so-called good roads movement. The physical, structural, and mechanical aspects of construction and maintenance are now quite well in hand. The engineering forces are now being confronted with a third major stage, that of operations in traffic engineering, dealing directly with movement. This third stage has reached a critical point on account of the enormous increase in the number and velocity of vehicles. It emphasizes the end-product function of highway departments, namely, transportation rather than construction and maintenance.

12. This new problem deals with the roadway from the surface up rather than from the surface down. It is primarily concerned with the removal of the four basic frictions which are the fundamental causes of all accidents and congestion. This can be accomplished in full only by grade separations (or rotary traffic islands), medial dividers, multiple lanes, and insulation of the moving lanes by denying right of access except at controlled points where accelerating and decelerating lanes are provided. These functional elements of efficient design have been adequately demonstrated, and the chief problem from this point on will be to find more economical processes of providing them.

13. As speeds increase, lanes must be made wider, they must be designed to encourage drivers to keep to the right, and their utility must be guaranteed by adequate outside clearance. Shoulders must be provided for disabled vehicles and for "last fair chance" use in case of operating emergencies.

14. Between intersections, right-of-way must be insulated, sight distance improved, opportunities for safe passing increased, safe parking in emergencies provided, and multiple-lane roadways divided by physical means.

15. The intersection, junction, or interchange is the greatest single obstacle to traffic efficiency. Its outmoded form does not fit the functional demands of modern traffic movement, and it must undergo radical changes if accidents and congestion are to be reduced. Complicated or multiple intersections must be reduced to "standard" simple right-angle intersections. The number of conflicting movements must be reduced. The angles and speed differentials of convergence, divergence, and intersection must be completely controlled by design. Means of design control include the reduction of all open areas to maximum units of two operating lanes by islands and funneling throats, and the introduction of accelerating and decelerating lanes, rotary traffic islands, and grade separations.

16. Traffic islands, though highly valuable, must be introduced into the traffic stream with discrimination. Their ends facing approaching traffic must avoid the "natural path" of vehicles, must be started on tangents, and must be adequately protected by signs and illumination. Their width will depend upon the available space and the degree of physical control that is required.

17. Mechanical control devices must be adjusted to the characteristics of drivers and to the distance which the speed of approach requires for understanding a situation and reaching a decision. They must be made more simple and have higher attention-attracting values to compete with backgrounds.

18. One-way and through streets or preference streets should be used to a greater extent.

19. As night travel at higher speeds increases, additional delineation and illumination must be provided.

20. Additional control for the pedestrian must be provided through fences, tunnels, bridges, separate walkways, and special signals.

The processes of measuring the problem, selecting the proper tools for improvement, and economically justifying remedial measures must be vastly improved. The problem must be broken up into its elements. Facts must be obtained accurately to measure each factor; traffic patterns must be measured, and a balanced program prepared. Only by these planned methods can consistent improvement be made in the face of the mass of detail which this perpetually growing problem presents.

CONCLUSION

It has been said that no new field of endeavor has reached a point where it can properly be called an art or a science until it has been classified, all its individual parts isolated and related. The present volume has attempted to make a little progress in this direction.

It should again be emphasized that this effort has dealt almost exclusively with the principles, philosophy, and theory of the automotive transportation problem. It is recognized that theory is of no practical value unless it works. The ideas must be conceived, measured, tried out, and evaluated.

The entire field of traffic engineering is passing from the qualitative to the quantitative stage. It is sincerely hoped that emphasis from this point on will be toward increased research evaluation of the principles which have been developed.

To write on the subject of automotive transportation in a definitive and conclusive way at this stage of its rapid development is impossible. The most that can be accomplished is to establish certain reasonable patterns supported by experience, logic, reasoning, and the smattering of available facts.

The reader is thus urged not to consider the statements in this presentation as "the last word" but rather as aimed to stimulate his own study. Undoubtedly, exceptions will be taken to many points, and it will require many years of practical adjustments before there is general agreement on some of them. However, if this material serves to give the reader a broad picture of the problem, to show him the relationship between its parts, and to indicate certain trends, it will have been a worthwhile effort.

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American Road Builders Association, National Press Bldg., Washington, D. C.

American Society of Civil Engineers, 33 West 39 St., New York, N. Y.

American Society of Planning Officials, 1313 E. 60 St., Chicago, Ill.

Highway Research Board, 2101 Constitution Avenue, Washington, D. C.

Institute of Traffic Engineers, 60 John St., New York, N. Y.

National Safety Council, 20 N. Wacker Drive, Chicago, Ill.

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American City. Published monthly by American City Magazine Corporation, New York.

American Highways. Published quarterly by American Association of State Highway Officials, Press Bldg., Washington, D. C.

Civil Engineering. Published monthly by American Society of Civil Engineers. Publ. Office, 20th and Northampton Sts., Easton, Pa.

Engineering News-Record. Published weekly by McGraw-Hill, Albany, N. Y.

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Public Roads. Published monthly by the Federal Works Agency, Public Roads Administration, Washington, D. C.

Public Safety. Published monthly by National Safety Council, Chicago, Ill.

The Planners' Journal. Published quarterly by American Institute of Planners, Hunt Hall, Cambridge, Mass.

Traffic Engineering. Published monthly by Institute of Traffic Engineers, New York, N. Y.

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GEOGRAPHICAL DIRECTORY

of

1. Heads of City and State Traffic Engineering Divisions.
2. Managers of State Highway Planning Surveys.
3. Members of the Institute of Traffic Engineers.
4. Reviewers of this book.
5. Graduates and Graduate Students of the Bureau for Street Traffic Research, Yale University.
6. Engineering Graduates of the Short Courses of the Bureau for Street Traffic Research, Yale University.

This geographic directory of persons associated with traffic engineering should not be considered as comprehensive. It contains only those persons coming under the six groups listed above. Those men who have generously contributed their time to review the manuscript of the book are marked with an asterisk (*). This list has been compiled with the assistance and cooperation of the Institute of Traffic Engineers.

It is hoped that this list will be of value to professional men who have frequent occasion to get in touch with personnel in traffic throughout the country.

LOCATION		HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
ALABAMA					
Eufaula	*				GARRETT, FRANK B., Resident Engineer, State Highway Department; Bureau for Street Traffic Research Graduate, 1939; reviewed book.
Montgomery					DINSMORE, L. M., Traffic Service Engineer, State Highway Department.
			HARVEY, A. R., Jr., State Manager, Highway Planning Survey, 210 State Highway Building.		
	*				SHERLOCK, CHRIS J., State Highway Director, Alabama State Highway Department; reviewed book.
					TAYLOR, MARVIN, State Maintenance Engineer, State Highway Department.
ARIZONA					
Phoenix					BROMLEY, FRANK W., Traffic Engineer, City Engineering Department; Bureau for Street Traffic Research Short Course, 1938.
	*				MILLER, EARLE V., Traffic Engineer and Chief, Division of Plans, State Highway Department; Bureau for Street Traffic Research Short Course, 1938; reviewed book.
	*				PARK, JOHN C., Associate Professor of Civil Engineering, University of Arizona, Tucson; reviewed book.
					PRICE, WILLIAM N., Assistant to Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
	*				PROCTER, JOHN M., Chairman, Arizona State Highway Commission; reviewed book.
			RATH, A. F., State Manager, Highway Planning Survey, 17th Avenue and Jackson St.		
Tucson	*				HOUSTON, GEORGE B., Traffic Engineer, and Assistant Superintendent of Streets; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
	*				SEELEY, GEORGE W., City Manager; reviewed book.
ARKANSAS					
Little Rock	*		HERRING, FRED J., State Manager, Highway Planning Survey; Principal Highway Engineer, Statistics and Analysis, State Highway Department; Bureau for Street Traffic Research Short Course, 1939; reviewed book.		
	*				JACKSON, J. RICHARD, Assistant Traffic Engineer, Arkansas State Highway Department; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
	*				MITCHELL, W. W., Director of Highways, Arkansas State Highway Commission; reviewed book
					PENDERGRAFT, CARL B., Office Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1939.
	*				ZASS, WILLIAM W., Chief Engineer, State Highway Commission; reviewed book.
CALIFORNIA					
					McCLINTOCK, LEONARD, Bureau for Street Traffic Research Graduate, 1931.
Auburn					EDELSTEIN, ALVIN, JR., Engineer, Box 792, c/o U. S. Engineers; Bureau for Street Traffic Research Graduate 1939.
Los Angeles					BANKHEAD, MELVIN J., Traffic Engineer, County of Los Angeles Road Department; on leave—Captain, Coast Artillery, Fort McArthur, California; Member ITE.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Los Angeles (*Contd.*)				DORSEY, RALPH T., City Traffic Engineer, Room M-68, City Hall; Member ITE.
				* EVANS, HENRY K., Assistant in Traffic Engineering, Automobile Club of So. California, 2601 So. Figueroa Street; Junior ITE; Bureau for Street Traffic Research Graduate, 1939; reviewed book.
				HATTON, RUSSELL C., Inspector Engineering Materials, U. S. War Department; Assoc. ITE.
				KAPLAN, JOSEPH M., Director of Public Education, Greater Los Angeles Safety Council, 572 Chamber of Commerce Building; Bureau for Street Traffic Research Graduate, 1938.
				LEFFERTS, E. B., Manager, Public Safety Department, Automobile Club of Southern California, 2601 So. Figueroa Street; Member ITE.
Manhattan Beach				TAYLOR, CLARENCE P., Aircraft Engineer, North American Aviation Company, 333 Third Street; Bureau for Street Traffic Research Graduate, 1929.
Oakland				CZIZEK, JAY A., JR., Traffic Engineer, Division of Traffic Engineering, City Hall; Assoc. ITE
				* MYERS, FRANK C., Designing Draftsman and Acting Traffic Engineer, City Hall; on leave—Base Maintenance Officer, Marine Base, San Diego, California; Bureau for Street Traffic Research Short Course, 1938; reviewed book; Assoc. ITE.
				* SHATTUCK, I. S., Traffic and Planning Consultant, 1404 Franklin Street; Member ITE; reviewed book.
Sacramento				CARTER, F. M., Assistant Traffic and Safety Engineer, Division of Highways, California Department of Public Works, 422 Public Works Building; Member ITE.
				* DENNIS, T. H., Maintenance Engineer, State Division of Highways, Public Works Building; reviewed book.
				* FAUSTMAN, JACKSON, Assistant Planning and Traffic Engineer, Sacramento; on leave—Lieutenant, Corps of Engineers, U. S. Army, Box 63, Hamilton Field, California; Junior ITE; Bureau for Street Traffic Research Graduate, 1938; reviewed book.
				HARRIS, MILTON, Assistant Safety Engineer, Division of Highways, 439 Public Works, P.O. Box 1449; Assoc. ITE.
				JAQUETH, HERBERT H., City Planning and Traffic Engineer.
				MacLACHLAN, K. A., State Manager, Highway Planning Survey, Division of Highways, 604 Plaza Building.
				* PURCELL, CHARLES H., State Highway Engineer, Department of Public Works; reviewed book.
				* VICKREY, J. W., Safety Engineer, Division of Highways, Public Works Building; reviewed book.
San Bernardino				WOOLVERTON, MARGARET, Traffic Engineer, San Bernardino Traffic and Safety Commission; Bureau for Street Traffic Research Short Course, 1939.
San Francisco				* SHOAF, ROSS T., Assistant Traffic Engineer, Room 286 City Hall; Bureau for Street Traffic Research Graduate, 1940; Junior ITE; reviewed book.
				* PURSER, GEORGE, Traffic Engineer, Department of Public Works, City and County of San Francisco, Room 286, City Hall; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
San Luis Obíspo	*			**GALLAGHER, CHAS. R.**, Junior Highway Engineer, State Division of Highways, District V; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
Tarzana				**DeYOUNG, WARREN E.**, District Manager, Automatic Signal Corporation, 5166 Avenida Hacienda; Assoc. ITE.
COLORADO				
Denver	*			**BUXTON, CHARLES F.**, Traffic Supervisor, Colorado Statewide Highway Planning Survey, 111 East 13th Ave.; reviewed book.
				BABB, CLAUD M., Traffic Division, Supervisor, State Highway Department.
	*			**DUNWOODY, HAROLD S.**, Assistant Manager, Colorado Highway Planning Survey; reviewed book.
	*			**FURLONG, JOHN E.**, Manager, Colorado Highway Planning Survey, State Highway Department; reviewed book.
	*			**McCORMACK, C. E.**, Traffic Manager, Colo. Highway Planning Survey, 111 East 13th Avenue; reviewed book.
	*			**ORMSBEE, DAN W.**, Construction Engineer, Colorado State Highway Department, State Office Building, reviewed book.
	*			**PEPPER, ALLAN R.**, Field Superintendent, Traffic Division, State Highway Department; Bureau for Street Traffic Research Short Course, 1938; reviewed book.
	*			**STANDRING, HENRY A.**, In Charge of Report on Highway Needs to State Legislature, State Highway Planning Survey, 111 East 13th Avenue; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
	*			**VAIL, CHARLES D.**, State Highway Engineer; reviewed book.
	*			**WIDMAIER, S. E.**, Field Statistician, Traffic Division, State Highway Department; Bureau for Street Traffic Research Short Course, 1938; reviewed book.
CONNECTICUT				
East Norwalk				**EAMES, E. H.**, Traffic Engineer, Automatic Signal Corporation, Regent Street; Assoc. ITE.
				GREEN, PAUL L., Sales Manager, Automatic Signal Corporation, Regent Street; Assoc. ITE.
Greenwich	*			**MINOR, PIERPONT L.**, Bureau for Street Traffic Research Graduate, 1941; reviewed book.
Hartford	*			**BUTTERFIELD, STEPHEN E.**, Traffic Engineer, Division of Highway Control, Connecticut State Highway Department, State Office Building; Junior ITE; Bureau for Street Traffic Research Graduate, 1939; reviewed book.
	*			**COX, WILLIAM J.**, Commissioner State Highway Department; reviewed book.
				CREAMER, W. M., State Manager, Highway Planning Survey, State Highway Department, State Office Building.
				DORRANCE, WILLIAM T., Junior Highway Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				EGAN, WILLIAM E., Secretary of Traffic Commission and Traffic Engineer, Municipal Bldg.; Bureau for Street Traffic Research Graduate, 1938.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Hartford (*Contd.*)	**HANSEN, WILLIAM C.**, Traffic Engineer, Motor Vehicle Department.			
	HOOPER, CURTIS J., Traffic Survey Manager, Connecticut State Highway Department; Bureau for Street Traffic Research Short Course, 1937.			
	KAEHRLE, MARTIN A., Junior Highway Engineer, State Highway Department; Bureau for Street Traffic Research Graduate, 1941.			
	LUNDEN, SELIM O., Highway Permits Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.			
	OSTERHOUDT, EARLE W., Assistant Engineer of Highway Control, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.			
	* **PERKINS, ERNEST T.**, Assistant Highway Engineer, State Highway Department; Bureau for Street Traffic Research Graduate, 1941; reviewed book.			
	* **SHARP, W. HOWARD**, Engineer of Highway Control, Highway Commission, State House, Hartford; reviewed book.			
	* **TWISS, FRANCIS E.**, Assistant Engineer, Department of Engineering, Municipal Building, Bureau for Street Traffic Research Graduate, 1939; reviewed book.			
New Haven	**BURKHARD, BRYANT**, Research Assistant, Bureau for Street Traffic Research, Yale University; Bureau for Street Traffic Research Graduate, 1937.			
	FORBES, THEODORE W., Research Assistant, Assistant Professor, Bureau for Street Traffic Research, Yale University; Affil. ITE; Bureau for Street Traffic Research Graduate, 1937.			
	FRISBEE, WILLIS H., JR., Research Assistant, Driver Research Center, Institute of Human Relations, Yale University; Bureau for Street Traffic Research Graduate, 1937.			
	HALSEY, MAXWELL N., Associate Director, Bureau for Street Traffic Research, Yale University; Bureau for Street Traffic Research Graduate, 1927; Member ITE.			
	* **HEALY, KENT T.**, Associate Professor of Economics, Yale University; reviewed book.			
	MATSON, THEODORE M., Research Assistant, Bureau for Street Traffic Research, Yale University; Member ITE.			
	McCLINTOCK, MILLER, Director, Bureau for Street Traffic Research, Yale University; Member ITE.			
	* **SUTTIE, ROSCOE H.**, Associate Professor, Civil Engineering, Yale University; reviewed book.			
	WILLIAMS, LESLIE, Research Assistant, Bureau for Street Traffic Research, Yale University; Bureau for Street Traffic Research Graduate, 1938; Junior ITE.			
Saugatuck	**ENO, WM. PHELPS**, Founder and Chairman of Board of Directors, Eno Foundation for Traffic Control, Inc.; Hon. ITE.			
	* **TILDEN, CHARLES J.**, President and Managing Director, Eno Foundation for Highway Traffic Control, Inc.; Professor of Engineering Mechanics, Emeritus, Yale University, New Haven, Connecticut; Member ITE; reviewed book.			
DELAWARE				
Dover	* **MACK, WARREN W.**, Chief Engineer, State Highway Department; reviewed book.			

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS

Dover (*Contd.*)

* **McKENDRICK, W. B., JR.**, Traffic Engineer.

McKENDRICK, W. B., JR., State Manager, Highway Planning Survey, State Highway Department; Bureau for Street Traffic Research Graduate, 1940; reviewed book.

Wilmington

HARRIS, WELTON W., Assistant Superintendent of Transportation, Delaware Electric Power Co., 600 Market St.; Assoc. ITE.

KOESTER, EDWIN F., City Traffic Engineer, City of Wilmington, P. O. Box 2; Assoc. ITE.

DIST. OF COLUMBIA

Washington

ALLGAIER, EARL, Driver Research Safety Department, American Automobile Association, 17th Street and Pennsylvania Avenue; Junior ITE.

BOARDMAN, WILLIAM F., Assistant Engineer, Capital Transit Company; Bureau for Street Traffic Research Student, 1941.

* **BROWN, WILFRED E.**, Engineering Representative, Automotive Brake Advisory Committee, 515 14th Street; Bureau for Street Traffic Research, 1937; reviewed book.

BULLIS, LEWIS V., Consultant, Traffic and Transportation Survey and Records Projects, Works Projects Administration; Assoc. ITE.

CRUM, ROY W., Director, Highway Research Board, 2101 Constitution Avenue; Affil. ITE.

* **DAMON, NORMAN**, Director, Automotive Safety Foundation, Tower Building; reviewed book.

ECKER, JOHN B., Research Engineer, Capital Transit Company, 36th and M Streets, N. W.; Assoc. ITE.

ELDRIDGE, M. O., Assistant Director, Department of Vehicles and Traffic, 451 Pennsylvania Avenue, N. W.; Member ITE.

ELIOT, WILLIAM G., 3rd, Highway Economist, U. S. Public Roads Administration; Assoc. ITE.

HEDGCOCK, L. M., State Manager, Highway Planning Survey, District Building.

HOLMES, EDWARD H., Highway Engineer Economist, Public Roads Administration; Bureau for Street Traffic Research Graduate, 1930; Assoc. ITE.

* **HOOVER, J. EDGAR**, Director Federal Bureau of Investigation, U. S. Department of Justice; reviewed book.

JAMES, EDWIN W., Chief, Division of Highway Transport, U. S. Public Roads Administration, Willard Bldg.

JOHNSON, LEVERNE, Safety and Traffic Engineering Department, American Automobile Association; Junior ITE.

LEWIS, RALPH S., Associate Highway Engineer Economist, Division of Control, U. S. Public Roads Administration; Junior ITE.

* **McGILL, C. C.**, Public Relations, Automotive Safety Foundation, Tower Building; reviewed book.

* **MARSH, BURTON W.**, Director, Traffic and Safety Engineering Division, American Automobile Association; Member ITE; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Washington (*Cont.*)				**PEABODY, LEROY E.,** Senior Highway Economist, U. S. Public Roads Administration; Member ITE.
	*			**PRISK, CHARLES W.,** Planning Survey Engineer, Public Roads Administration; Bureau for Street Traffic Research Graduate, 1939; reviewed book.
				RYDER, JAMES A., Engineer, National Capitol Park and Planning Commission; Bureau for Street Traffic Research Short Course, 1937.
				STUPKA, PETER J., Assistant Traffic Engineer, Work Projects Administration, 19th and E Streets, N. W.; Member ITE.
				STARK, MARTIN C., Research Assistant, Capital Transit Company, 36th and M Streets, N. W.; Junior ITE; Bureau for Street Traffic Research Graduate, 1938.
	*			**TILLEY, ALBERT C.,** Field Representative, Division of State and Local Co-operation, Advisory Commission to the National Defense Council; reviewed book.
				TUTTLE, LAWRENCE S., Senior Highway Engineer, U. S. Public Roads Administration; Assoc. ITE; Bureau for Street Traffic Research Graduate, 1930.
				UPHAM, CHARLES M., JR., Bureau for Street Traffic Research Short Course, 1940; Bureau for Street Traffic Research Graduate, 1941.
	*			**UPHAM, CHARLES M., SR.,** Engineer Director, American Road Builders' Association, International Bldg., 1319 F Street, N. W.; reviewed book.
	*			**VAN DUZER, WILLIAM A.,** Director, Department of Motor Vehicles and Traffic, 451 Pennsylvania Avenue, N. W.; Member ITE; reviewed book.
	*			**WEAVER, C. REYNOLDS,** Assistant to Director, Automotive Safety Foundation, Tower Building; at present Captain, War Department General Staff, Transportation Branch, 2124 Munitions Building; reviewed book.
FLORIDA				
Ft. Lauderdale	*			**PRINDLE, M. L.,** Haskins and Company, 920 East Las Olas Boulevard; reviewed book.
Miami	*			**HOOVER, JOHN L.,** Traffic Inspector, Police Department, Miami Beach; Bureau for Street Traffic Research Short Course, 1939; reviewed book.
				VANDERSTEMPEL, T. M., Traffic Engineer, Miami Transit Company, 121 S. E. First Street; Assoc. ITE.
Tallahassee				**GRUNOW, ROBERT N.,** Associate Highway Engineer Economist, Public Roads Administration, Box 1079; Assoc. ITE.
				PARKER, WALTER, McF., State Manager, Highway Planning Survey; Division Engineer, Division of Research and Records, Florida State Road Department; Bureau for Street Traffic Research Short Course, 1937.
				RONAN, FRANK A., Statistician, Division of Research and Records, Florida State Road Department; Bureau for Street Traffic Research Short Course, 1937.
GEORGIA				
Atlanta	*			**BAHIN, L. J.,** Contact Engineer (Federal); reviewed book.
				BEVINS, KARL A., Transportation Department, Georgia Power Company; Bureau for Street Traffic Research Graduate, 1941.
	*			**BISHOP, MITCHELL C.,** Director, Division of Traffic and Safety, State Highway Department; Bureau for Street Traffic Research Short Course, 1940; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Atlanta (*Cont.*)	*			**DIER, ROBERT D.**, Assistant Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
				HAYES, FRANK, State Highway Board of Georgia; Bureau for Street Traffic Research Short Course, 1940.
				HENDON, J. W., Field Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				JONES, RALPH K., Bridge Designer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				KENNEDY, JAMES A., Chief Draftsman, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				LAMB, T. D., JR., Assistant Division Engineer (Maintenance), State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				LAWSON, HERBERT F., Engineer-Clerk and Assistant Statistician, State Highway Board; Bureau for Street Traffic Research Short Course, 1940.
	*			**NEEL, WARREN R.**, State Highway Engineer, State Highway Department, 2 Capitol Square; reviewed book.
	*			**PAPAGEORGE, GEO. T.**, Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
				RAY, O. T., State Manager, Highway Planning Survey, 2 Capitol Square.
				SEAY, F. A., Assistant Construction Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				TORRAS, RAYMOND W., Engineer Secretary, City Planning Commission; Bureau for Street Traffic Research Short Course, 1937.
Augusta				**RAY, R. G., JR.**, Associate Engineer, U. S. Engineering Corps, Bureau for Street Traffic Research Short Course, 1940.
Fitzgerald				**HERRINGTON, CHAUNCEY E.**, Resident Engineer, Georgia State Highway Board; on leave—Camp Davis, Holly Ridge, North Carolina; Bureau for Street Traffic Research Short Course, 1940.
Fulton County				**EPPERSON, L. R.**, Assistant County Engineer; Bureau for Street Traffic Research Short Course, 1940.
Gainesville				**POUND, J. H.**, Senior Resident Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				RICHARDSON, J. N., Assistant Division Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
Macon				**CHAPMAN, CLAUDE P.**, Assistant Division Engineer, Georgia State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
Marietta				**HARRIS, EDWARD H.**, Assistant District Superintendent (Office Engineer), District No. 4, Work Projects Administration; Bureau for Street Traffic Research Short Course, 1940.
Valdosta				**EDMUND, H. P.**, City Engineer; Bureau for Street Traffic Research Short Course, 1940.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS

IDAHO

Boise

CHAMBERLIN, J. A., State Manager, Highway Planning Survey, 300 First National Bank Building.

MATHES, ELLIS L., Traffic and Safety Engineer, Idaho Department of Public Works, Bureau of Highways; Bureau for Street Traffic Research Graduate, 1941.

ILLINOIS

Chicago

ABBOTT, WILLIAM R., JR., Automatic Signal Corporation, 400 North Michigan Avenue; Assoc. ITE.

BAKER, J. STANNARD, Traffic Safety Consultant, Public Safety Division, National Safety Council, 20 No. Wacker Drive; Assoc. ITE.

* **BARTON, GEORGE W.**, Director, Safety and Traffic Engineering Department, Chicago Motor Club, 66 East South Water Street; Member ITE; reviewed book.

BAUMEL, EDWARD J., Junior Traffic Engineer, Traffic Engineering Section, Chicago Park District, Administration Building; Burnham Park; Junior ITE.

BERRY, DONALD S., Traffic Engineer, National Safety Council, 20 North Wacker Drive; Assoc. ITE.

* **BOOTH, HARVEY D.** Traffic Engineer, National Safety Council, 20 North Wacker Drive; Bureau for Street Traffic Research Short Course, 1939; reviewed book.

BRAFF, LLOYD M., Assistant Traffic Engineer, Chicago Surface Lines, 231 South LaSalle Street; Assoc. ITE.

BRANDES, WILLIAM C., Traffic Signal Engineer, Bureau of Streets, 401 City Hall; Member ITE.

CALABRESE, SAMUEL S., Traffic Investigator, Chicago Park District; Bureau for Street Traffic Research Short Course, 1937.

HOFER, VICTOR G., Assistant Traffic Engineer, Traffic Engineering Section, Chicago Park District, Administration Building, Burnham Park; Assoc. ITE.

JASPER, RUFUS G., Traffic Engineer, Traffic Engineering Bureau, National Safety Council, 20 North Wacker Drive; Assoc. ITE.

JELINEK, OTTO K., Traffic Engineer, Traffic Engineering Section, Chicago Park District, Administration Building, Burnham Park, Member ITE.

KRAG, MATHEW, Traffic Engineering Designer, Chicago Park District; Bureau for Street Traffic Research Short Course, 1937.

MASSEN, JOHN B., International City Managers' Association, 1313 East 60th Street; Bureau for Street Traffic Research Graduate, 1938.

McCONOCHIE, WILLIAM R., Traffic Engineer, Chicago Surface Lines, Room 1473, 231 South LaSalle Street; Member ITE.

McCROSKEY, THEODORE T., Executive Director, Chicago Planning Commission, 20 No. Wacker Drive; Assoc. ITE.

McILRAITH, EVAN J., Staff Engineer, Chicago Surface Lines, 231 South LaSalle Street; Member ITE.

MICHEL, RALPH F., Junior Electrical Engineer, Division of Electrical Engineering, Room 613, City Hall; Affil. ITE.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSFICATIONS

Chicago (*Cont.*)

MUNCH, GUSTAVE E., Vice President and General Manager, Welbach Traffic Signal Company, 122 South Michigan Avenue; Affil. ITE.

NAU, ROBERT H., Secretary, Street Traffic Committee, Public Improvements Committee, Chicago Association of Commerce, One North LaSalle Street; Member ITE.

PORTER, HARRY, JR., District Traffic Engineer, Illinois Division of Highways, 35 East Wacker Drive; Assoc. ITE.

REEDER, EARL J., Chief Traffic Engineer, National Safety Council, 20 North Wacker Drive; Member ITE.

REX, CHARLES H., Special Representative, General Electric Company, 230 South Clark Street; Member ITE.

SCHANTZ, GEORGE, Sales Engineer, Industrial Department, International Harvester Company, 1505 W. 41st Street, LaGrange; Junior ITE.

* **SHUMAN, EVERETT C.,** Department of Civil Engineering, Lewis Institute, 1951 West Madison Street; reviewed book.

SIELSKI, MATTHEW C., Assistant Traffic Engineer, Safety and Traffic Engineering Department, Chicago Motor Club, 66 East South Water Street; Junior ITE.

* **SORENSON, HAROLD T.,** Junior Subway Engineer, Department of Subways and Super Highways, 20 North Wacker Drive; Bureau for Street Traffic Research Graduate, 1939; reviewed book.

SORENSON, LESLIE J., City Traffic Engineer, Bureau of Streets, Department of Streets and Electricity, 401 City Hall; Member ITE.

SPEARS, SHOLTO M., Associate Professor Civil Engineering, Illinois Institute of Technology; Bureau for Street Traffic Research Short Course, 1938.

STRAETZ, A. G., Sales Manager, Kopp Glass, Inc., 205 West Wacker Drive; Member ITE.

TAYLOR, PHILLIP E., Traffic Engineering Designer, Traffic Engineering Section, Chicago Park District, Administration Building, Burnham Park; Assoc. ITE.

* **WILLIAMS, SIDNEY J.,** Director, Public Safety Division, National Safety Council, 20 North Wacker Drive; Member ITE; reviewed book.

* **WOODBURN, BERT W.,** JR., Auditor, The Advertising Research Foundation, Inc., 201 North Wells Street; Bureau for Street Traffic Research Graduate, 1939; reviewed book.

East St. Louis

CRAWLEY, VERLE C., District Traffic Engineer, Illinois Division of Highways, 9300 St. Clair Avenue; Assoc. ITE.

Effingham

WILEY, CARL H., District Traffic Engineer, Illinois Division of Highways, Box 152; Assoc. ITE.

Evanston

FAULKNER, Z. A., City Traffic Engineer, Department of Public Works, City Hall, Sherman Avenue and Davis Street; Junior ITE.

FORSTER, A ROBERT, Director of Training, Northwestern University Traffic Institute, 1827 Orrington Avenue, Bureau for Street Traffic Research Graduate, 1937.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Evanston (*Cont.*)				KREML, FRANKLIN M., Lieut. Director Safety Division, International Association of Chiefs of Police, 1827 Orrington Avenue; Affil. ITE.
				LOVELESS, THEODORE, Field Representative, Safety Division, International Association of Chiefs of Police, 1827 Orrington Avenue; Bureau for Street Traffic Research Graduate, 1937.
Peoria				CRAWFORD, JAMES H., City Traffic Engineer, Department of Public Works, City Hall.
Springfield				BARKER, F. N., State Manager, Highway Planning Survey, Laboratory Building, 126 East Ash Street.
		*		HARRISON, HARRY H., Traffic Engineer, Illinois Division of Highways, 416 Centennial Building; Member ITE; reviewed book.
				McCARTY, JOSEPH C., Junior Highway Engineer, Highway Research Division, Illinois Highway Department; Bureau for Street Traffic Research Graduate, 1941.
		*		RIDGE, MERTON E., Assistant Traffic Engineer, Division of Highways, 416 Centennial Building; Bureau for Street Traffic Research Short Course, 1939; reviewed book.
				TOWERS, JOHN L., Assistant Traffic Engineer, Illinois Division of Highways, 416 Centennial Building; Assoc. ITE.
Urbana				WILEY, C. C., Professor, Civil Engineering, University of Illinois, 103 Engineering Hall; Member ITE.
INDIANA				
Crawfordsville				JOHNSTON, W. A., Assistant District Engineer, Traffic Division; Bureau for Street Traffic Research Short Course, 1938.
Fort Wayne		*		BOWMAN, LLOYD A., Assistant District Engineer, Traffic Division, State Highway Commission; Bureau for Street Traffic Research Short Course, 1938; reviewed book.
				WHITE, JAMES T., Traffic Engineer, City Hall; Bureau for Street Traffic Research Short Course, 1938, 1940.
Gary		*		KANE, LAURENCE A., Traffic Engineer, Old City Hall; Bureau for Street Traffic Research Short Course, 1939; Bureau for Street Traffic Research Graduate, 1940; Assoc. ITE; reviewed book.
		*		LEWIS, TAYLOR D., Traffic Engineer, Old City Hall; on leave—Lieutenant, 9th Signal Company, Ft. Bragg, North Carolina; Assoc. ITE; Bureau for Street Traffic Research Graduate, 1937; reviewed book.
Indianapolis		*		BENDER, LOUIS E., Assistant Traffic Engineer, State Highway Commission of Indiana, State House Annex; Assoc. ITE; reviewed book; Bureau for Street Traffic Research Short Course, 1938; Bureau for Street Traffic Research Graduate, 1940.
				BREWER, PAUL, State Manager, Highway Planning Survey, 217 North Senate Avenue.
				MILNER, WILLIAM F., Assistant Traffic Engineer, State Highway Commission of Indiana, 3736 North Pennsylvania Street; Assoc. ITE.
		*		MORIARTY, JOHN B., Traffic Engineer, State Highway Commission of Indiana, State House Annex; Bureau for Street Traffic Research Short Course, 1940; Assoc. ITE; reviewed book.
		*		MYERS, HALLIE, Director of Traffic, Indiana State Highway Commission; Bureau for Street Traffic Research Short Course, 1940; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Indianapolis (*Cont.*)	*			**SCHAFER, N. F.**, Engineer of Maintenance, State Highway Commission of Indiana; reviewed book.
	*			**WETZEL, EDWARD G.**, District Traffic Engineer, State Highway Commission; Bureau for Street Traffic Research Graduate, 1941; Junior ITE; reviewed book.
LaPorte	*			**RICHARD, A. B.**, Bureau for Street Traffic Research Short Course, 1938; reviewed book.
South Bend	*			**ELLIOTT, K. B.**, Vice President, Studebaker Corporation of America; reviewed book.
	*			**HOFFMAN, PAUL G.**, President, Studebaker Corporation of America; Hon. ITE; reviewed book.
	*			**JAMES, WILLIAM S.**, Chief Engineer, Studebaker Corporation of America; reviewed book.
	*			**MILLER, ERNEST H.**, City Traffic Engineer; Bureau for Street Traffic Research Short Course, 1938; Junior ITE; reviewed book.
Vincennes	*			**SMYTHE, JAMES F.**, District Traffic Engineer, State Highway Commission of Indiana, P. O. Box 340; reviewed book.
IOWA				
Ames				**ANDERSON, CARL B.**, Road Designer in Charge of Road Plan Division, Iowa Highway Commission; Bureau for Street Traffic Research Short Course, 1940.
	*			**BURCH, DAVID W.**, Safety Engineer, Safety and Traffic Department, Iowa State Highway Commission; reviewed book.
	*			**DAMON, PHILIP E.**, Iowa State Highway Commission; reviewed book.
	*			**DAVIS, WILFRED W.**, Assistant Traffic Engineer, Safety and Traffic Division, Iowa State Highway Commission; Bureau for Street Traffic Research Graduate, 1940; Assoc. ITE; reviewed book.
				FYE, RUSSELL C., Maintenance Office Engineer, State Highway Commission, 715 Burnett Avenue; Bureau for Street Traffic Research Short Course, 1940.
	*			**MESSER, ROY T.**, Assistant Traffic Engineer, State Highway Commission; Bureau for Street Traffic Research Short Course, 1940; reviewed book.
	*			**MORRIS, MARK**, State Manager, Highway Planning Survey, State Highway Commission; Traffic Engineer, Iowa State Highway Commission; reviewed book.
	*			**PRICE, WILLIAM O.**, Engineer of Safety and Traffic, State Highway Commission; reviewed book.
Des Moines	*			**STEDMAN, HARRY E.**, Traffic Engineer, City of Des Moines; on leave, Lt. Col., 168th Infantry, 34th Division, A.P.O. 34, Camp Beauregarde, La.; Member ITE; reviewed book.
Humboldt				**FISHER, RUSSELL J.**, Sergeant Iowa Highway Safety Patrol, Box 427; Bureau for Street Traffic Research Graduate, 1937.
Ottumwa				**COOK, HENRY E.**, City Engineer, Traffic Engineer ex-officio, Ottumwa.
KANSAS				
Topeka				**HARBES, JOHN**, State Manager, Highway Planning Survey, Masonic Building.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Topeka (*Cont.*)	McCAMMENT, CLAUD R., Engineer of Safety and Traffic Control, State Safety Division, State Highway Commission of Kansas.			
				MAIER, EUGENE, Designer, Kansas Highway Commission, on leave—Captain, 69th Coast Artillery, Camp Hulen, Palacios, Texas; Bureau for Street Traffic Research Graduate, 1941.
				WILSON, BRYAN, Assistant Safety and Traffic Engineer, State Highway Commission; Bureau for Street Traffic Research Short Course, 1938, 1940.
KENTUCKY				
Frankfort	RINGO, W. P., Traffic Engineer, Dept. of Highways, Commonwealth of Kentucky.			
		STIGERS, J. F., State Manager, Highway Planning Survey, Louisiana Highway Commission, 319 Ann Street.		
				WATKINS, WILBERT F., Assistant Traffic Engineer, Department of Highways, Commonwealth of Kentucky; Bureau for Street Traffic Research Graduate, 1941.
Louisville	*		KIRWAN, E. EMMETT, Traffic Engineer, Department of Public Works, City Hall; Bureau for Street Traffic Research Graduate, 1937; Junior ITE; reviewed book.	
LOUISIANA				
Baton Rouge	DUPREE, SAM G., Traffic Engineer, Department of Highways; Bureau for Street Traffic Research Short Course, 1940.			
	*			FLANAKIN, HUBERT A., Planning Engineer, State Highway Department; Bureau for Street Traffic Research Graduate, 1941; reviewed book.
	*			HENDERLITE, HARRY B., Chief Engineer, Department of Highways; reviewed book.
		THOMAS, I. L., JR., State Manager, Highway Planning Survey, Louisiana Highway Commission.		
New Orleans	*			GIBSON, JAMES K., Research Assistant, Research Department, New Orleans Public Service, Inc.; Bureau for Street Traffic Research Graduate, 1939; reviewed book.
	*			NAQUIN, ARTHUR J., Transportation Engineer, New Orleans Public Service, Inc., 317 Baronne Street; Assoc. ITE; reviewed book.
				RICHAUD, GEORGE J., Employee Relations Assistant, New Orleans Public Service, Inc.; Bureau for Street Traffic Research Short Course, 1937.
	*			RISTROPH, PAUL L., Traffic Engineer, New Orleans Public Service, Inc.; on leave, Captain, Engineer School, Fort Belvoir, Va.; Bureau for Street Traffic Research Graduate, 1938; Assoc. ITE; reviewed book.
MAINE				
Augusta		EATON, FRED G., State Manager, Highway Planning Survey, State Highway Commission, State House.		
	* SAWYER, RALPH H., Traffic Engineer, State Highway Commission; Bureau for Street Traffic Research Graduate, 1939; reviewed book.			
MARYLAND				
Baltimore				ADLER, CHARLES, JR., Mount Royal Station; Affil. ITE.
	*			BRAUN, WALLACE L., Traffic Engineer, Baltimore Police Department, Fallsway and Fayette Streets; Bureau for Street Traffic Research Graduate, 1937; Affil. ITE; reviewed book.
		CHILDS, W. F., JR., State Manager, Highway Planning Survey, Old Town Bank Building, Gay Street and Fallsway.		

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS

Baltimore (*Cont.*)

LEWIS, GEORGE N., JR., Traffic Manager, Maryland State Road Commission; Bureau for Street Traffic Research Short Course, 1939.

* REINDOLLAR, ROBERT M., Assistant Chief Engineer, State Roads Commission, Department of Public Works, Federal Reserve Bank; reviewed book.

MASSACHUSETTS

Boston

* BEAL, THOMAS P., President, Second National Bank, 75 Federal Street; reviewed book.

* BILLINGS, WILLIAM E., Fleet Engineer, Liberty Mutual Insurance Co.; Bureau for Street Traffic Research Graduate, 1937; reviewed book.

BURNS, JAMES D., Assistant Designing Engineer, Transit Department, 1 Beacon Street; Bureau for Street Traffic Research Short Course, 1937.

CRESSY, J. C., State Manager, Highway Planning Survey, Department of Public Works, 100 Nashua Street.

* COPELL, EDGAR F., Traffic Engineer, Commonwealth of Mass., 100 Nashua Street; Member ITE; reviewed book.

CREEDON, TIMOTHY E., Director, Community Traffic Safety Division, Massachusetts Safety Council, 80 Federal Street; Bureau for Street Traffic Research Graduate, 1937.

DESMOND, PHILIP T., Traffic Engineer, Boston Traffic Commission, 134 North Street.

HIGGINS, HARRY A., Traffic Signal Engineer, Boston Traffic Commission, 134 North Street; Bureau for Street Traffic Research Short Course, 1937.

KENNARD, WENTWORTH, Shreve, Lamb & Harmon; Fay, Spofford & Thorndike, Architects-Eng., Newfoundland Base Project, 11 Beacon St.; Bureau for Street Traffic Research Graduate, 1937.

KURKJIAN, BAHAN B., Public Administration Service, 11 Beacon Street; on leave, War Department, Hartford Ordnance District, Industrial Service Section, 95 State Street, Springfield, Mass.; Bureau for Street Traffic Research Short Course, 1937.

* McCRACKEN, DWIGHT M., Director, Traffic and Safety Bureau, Liberty Mutual Insurance Company, 175 Berkeley Street; Bureau for Street Traffic Research Graduate, 1931; Member ITE; reviewed book.

STEVENS, EDGAR F., Municipal Sales, Boston Edison Company; Bureau for Street Traffic Research Short Course, 1937.

THOMPSON, GEORGE H., Lieut., Massachusetts State Police, Commonwealth Pier, Bureau for Street Traffic Research Graduate, 1937.

Longmeadow

HOAG, RUSSELL, Traffic Engineer; Bureau for Street Traffic Research Short Course, 1937.

Lynn

HILTON, WILLIAM B, Assistant Engineer, City Engineer's Department; Bureau for Street Traffic Research Short Course, 1937.

REID, RALPH A., Designing Engineer on Traffic Control, General Electric Company; Member ITE.

Pittsfield

HOYT, F. RUSSELL, JR., 176 Pomeroy Avenue; Bureau for Street Traffic Research Graduate, 1941.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Springfield				HEALEY, CHARLES M., JR., Consultant, Traffic and Transportation Board, Department of Streets and Engineering; Bureau for Street Traffic Research Short Course, 1939.
Taunton				MACDONALD, DONALD S., Traffic Engineer, McCarty Freight System, Inc.; Bureau for Street Traffic Research Graduate, 1941.
Waltham				HOWE, HERBERT F., Foreman, Public Works Department; Bureau for Street Traffic Research Short Course, 1937.
West Hanover				HAYES, JAMES H., Director of Safety, National Fireworks, Inc.; Bureau for Street Traffic Research Short Course, 1936; Graduate, 1937.
Worcester *				GOVE, A. WALLACE, Manager, Worcester Citizens Traffic Safety Committee, Worcester Chamber of Commerce; Bureau for Street Traffic Research Graduate, 1941; reviewed book.
MICHIGAN				
Alpena				DOBELEK, JOHN J., District Traffic Engineer, Traffic and Safety Division, State Highway Department; Assoc. ITE.
Ann Arbor *				MORRISON, ROGER L., Professor, Highway Engineering and Highway Transport, Univ. of Michigan, East Engineering Bldg.; Member ITE; reviewed book.
Bay City				FRIER, HAROLD L., Junior Engineer, City Engineering Department; Bureau for Street Traffic Research Graduate, 1941.
Detroit				ARNTZ, H. G., Safety and Traffic Engineer, Auto Club of Michigan; Bureau for Street Traffic Research Short Course, 1939.
				DAVIS, ERNEST P., Traffic Engineer, Automobile Club of Michigan; Bureau for Street Traffic Research Short Course, 1938.
			*	KOCH, HARRY C., Associate Traffic Engineer, Traffic Engineering Bureau, 1300 Beaubien Street; Member ITE; reviewed book.
				McCASKE, HERBERT, Inspector, Traffic Survey Bureau, Detroit Police Department; Assoc. ITE.
			*	MICKLE, D. GRANT, Traffic Engineer, Detroit Traffic Engineering Bureau, 1300 Beaubien Street; Bureau for Street Traffic Research Graduate, 1931; Member ITE; reviewed book.
				MICKLE, D. GRANT, Consulting, Traffic and Safety Engineer, Michigan State Highway Department.
				MONARCH, JOHN T., Traffic Safety Inspector, Wayne County Road Commission, 3800 Barlum Tower; Bureau for Street Traffic Research Short Course, 1939.
				TILLAPAUGH, HOWARD W., Safety Engineer, Royal Indemnity Company, 519 Fisher Bldg.; Jun. ITE.
		*		UPHAM, JOHN E., Field Traffic Investigator, State Highway Department, 812 New Center Bldg.; Bureau for Street Traffic Research, 1940; Bureau for Street Traffic Research Short Course, 1939; reviewed book.
				WEHMEYER, JOE LaMAR, Safety Engineer, Wayne County Road Commission, 3800 Barlum Tower; Mem. ITE.
			*	WILEY, T. T., Assistant Traffic Engineer, Traffic Engineering Bureau, 1300 Beaubien Street; Assoc. ITE; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Detroit (*Cont.*)	*			**YOST, LIGHT B.**, Public Relations Department, General Motors Bldg., Grand Blvd. at 2nd; Bureau for Street Traffic Research Graduate, 1939; Affil. ITE; reviewed book.
East Lansing				**HAUN, HAROLD E.**, Chief of Police, East Lansing Police Department; Bureau for Street Traffic Research Graduate, 1937.
				GUNDERSON, OSCAR M., Traffic Engineer, Michigan State Police; Member ITE.
Flint	*			**OSBORNE, HENRY W.**, Traffic Engineer, Division of Police, Department of Public Safety; Bureau for Street Traffic Research Graduate, 1937; Assoc. ITE; reviewed book.
Jackson				**JAMESON, HUGH E.**, Police Traffic Bureau; Bureau for Street Traffic Research Short Course, 1938.
Kalamazoo				**BELKIN, MAJOR M.**, City Traffic Engineer.
Lansing	*			**ANDRIACCHI, LOUIS A.**, Assistant Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Graduate, 1941; Assoc. ITE; reviewed book.
				BAUERLE, HAROLD G., Highway Designing Engineer, 212 N. Hayford Avenue; Bureau for Street Traffic Research Short Course, 1939.
				BURR, KENNETH R., Bridge Project Engineer, State Highway Department; on leave, Associate Civil Engineer (Construction) for the Navy Department, Puget Sound Navy Yard, Bremerton, Washington; Bureau for Street Traffic Research Short Course, 1939.
				COOPER, HAROLD H., Bridge Design Engineer, Bureau for Street Traffic Research Short Course, 1939.
				CYBERSKI, BARNEY A., Draftsman, State Highway Department; Bureau for Street Traffic Research Short Course, 1939.
				FELICIOTTI, ARTHUR R., Project Engineer, Michigan State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				GERVAIS, EDWARD F., Traffic Signal Electrician, Michigan State Highway Department, 508 North Grand Avenue; Bureau for Street Traffic Research Short Course, 1939; Junior ITE.
	*			**GRAVELLE, GORDON K.**, Municipal Traffic Engineer, Traffic and Safety Division, Michigan State Highway Department; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
				HARGER, ROSS, Assistant Traffic Engineer, Detroit Traffic Engineering Bureau, 1300 Beaubien Street, Bureau for Street Traffic Research Short Course, 1939.
	*			**HARVIE, WILLIAM H.**, Road Engineer, Michigan State Highway Department; reviewed book.
				HEFRON, ROSCOE E., Assistant Traffic Safety Engineer, Michigan State Highway Department; Bureau for Street Traffic Research Short Course, 1937; Assoc. ITE.
				JACKSON, ROBERT W., Traffic and Safety Division, Michigan State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
	*			**KENNEDY, G. DONALD**, State Highway Commissioner, State Highway Department; reviewed book.
				LUTZ, RANDOLPH B., Design Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1939.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Lansing (*Cont.*)	*			**MALO, ALGER F.**, Acting Traffic and Safety Engineer, Michigan State Highway Department; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
				McMONAGLE, J. CARL, Assistant Director, Planning Division, Michigan State Highway Department; Assoc. ITE.
				MURRAY, JAMES V., Bridge Designing Engineer; Michigan State Highway Department; Bureau for Street Traffic Research Short Course, 1939.
				RADER, DONALD W., Highway Designing Engineer, Michigan State Highway Department; Bureau for Street Traffic Research Short Course, 1939.
				ROTHSTEIN, MAURICE, Bridge Designing Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1939.
				STEFFANS, EDWARD J., Assistant Traffic Research Analyst; State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				STEINFATT, WALTER L., Traffic Research Engineer, Planning Division, State Highway Department; Bureau for Street Traffic Research Short Course, 1939.
				TAYLOR, FRED C., State Manager, Highway Planning Survey, 508 North Grand Ave.
	*			**TIEDEMAN, G. W.**, Engineer of Road Design, State Highway Department; reviewed book.
				WALBERT, THOMAS P., Traffic Designing Engineer, Traffic and Safety Division, Michigan State Highway Department; Bureau for Street Traffic Research Graduate, 1941.
Plymouth				**BRZUCHOWSKI, JAMES W.**, District Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1939.
Pontiac				**LUCAS, ORRIN M.**, Water Meter Department, Department of Water Supply; Bureau for Street Traffic Research Graduate, 1941
MINNESOTA				
St. Paul	*			**DARRELL, JAMES E. P.**, Assistant Traffic Engineer, Minnesota Department of Highways, 1246 University Avenue; Bureau for Street Traffic Research Graduate, 1941; Assoc. ITE; reviewed book.
	*			**HENDRICKSON, LAURENCE E.**, Electrical Engineer, Traffic and Safety Division, Department of Highways; on leave—1st Lieutenant, 10th Signal Service Co., Fort Wm. McKinley, Philippine Islands; Bureau for Street Traffic Research Graduate, 1938; Junior ITE; reviewed book.
				HEWETT, MAURICE W., Senior Assistant Civil Engineer, Department of Public Works; Bureau for Street Traffic Research Short Course, 1938.
	*			**ROSENWALD, WALTER F.**, Traffic Engineer, Traffic and Safety Division, Department of Highways, 1279 University Avenue, Member ITE; reviewed book.
				SHORT, R. J., State Manager, Highway Planning Survey, 1246 University Avenue.
Duluth				**HORWITZ, AARON B.**, City Planning Engineer, Duluth City Planning Department, City Hall; Assoc. ITE.
Minneapolis				**VINCENT, JAY C.**, Traffic Engineer, City of Minneapolis, 203 City Hall; Member ITE.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS

MISSISSIPPI

Jackson

BROWN, I. W., State Manager, Highway Planning Survey, Howie Building, 152 South Lamar.

WALSH, J. H., JR., Director of Public Safety.

YATES, A. J., JR., Engineer of Maintenance (including traffic engineering functions).

MISSOURI

Columbia

SMITH, FRANCIS P., Instructor, Stephens College; Bureau for Street Traffic Research Graduate, 1938.

Jefferson City

BROOKS, RAYMOND W., Chief Designer, Surveys and Plans, State Highway Department; Bureau for Street Traffic Research Short Course, 1938.

CORDER, LEON W., Engineer of Signs and Marking, State Highway Department, Bureau of Maintenance; Bureau for Street Traffic Research Short Course, 1938.

* **GRIFFITH, HARRY D.**, Safety Engineer, State Highway Commission; reviewed book.

GWINN, ABNER, Associate Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1939.

* **HURD, FRED W.**, Traffic Engineer, Safety Bureau, State Highway Department; Bureau for Street Traffic Research Graduate, 1939; reviewed book.

LONG, J. H., State Manager, Highway Planning Survey, State Highway Department.

Kansas City

PALMER, GLENN E., Division Safety and Traffic Engineer, State Highway Department, 5117 East 31st Street; Bureau for Street Traffic Research Short Course, 1939.

* **SEBURN, THOMAS J.**, City Traffic Engineer, City Hall; Member ITE; reviewed book.

St. Louis

DIECKHAUS, RICHARD J., Superintendent, Maintenance and Construction, Traffic Division, Department of Streets and Sewers, City Hall; Junior ITE.

FEUCHTER, JOSEPH J., Traffic Engineer, Room 322, City Hall; Assoc. ITE.

HOFFMAN, REYBURN, Secretary Manager, St. Louis Safety Council, 511 Locust Street; Member ITE.

WILLIAMS, E. BRYAN, Chief Traffic Engineer, St. Louis Public Service Company, 3869 Park Avenue; Assoc. ITE.

St. Joseph

COOK, JEWELL T., City Traffic Engineer.

MONTANA

Helena

JAWORT, O. J., State Manager, Highway Planning Survey, State Highway Commission.

JONES, ALBERT W., Senior Detailer, Montana Highway Department; Bureau for Street Traffic Research Graduate, 1941.

NEBRASKA

Lincoln

* **BOHNER, A. W.**, Construction Engineer; Bureau for Street Traffic Research Short Course, 1939; reviewed book.

* **BUTCHER, MASON A.**, Traffic Field Engineer, Traffic Engineering Section, Department of Roads and Irrigation, State Capitol Building; Bureau for Street Traffic Research Graduate, 1940; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Lincoln (*Cont.*)		FOWLER, C. F., State Manager, Highway Planning Survey, Department of Roads and Irrigation, Capitol Building.		
	*	JOHNSTON, J. EDWARD, Traffic Office Engineer, Department of Roads and Irrigation, Traffic Engineering Section; Bureau for Street Traffic Research Graduate, 1940; reviewed book.		
	*			LOBDELL, A. T., Chief, Bureau of Roads; reviewed book.
Omaha				BRUNING, FRED, Traffic Engineer, Police Department; Bureau for Street Traffic Research Short Course, 1939.
NEVADA				
Carson City	*	HARTUNG, BERNARD C., Director, Traffic and Safety Division, Department of Highways; Bureau for Street Traffic Research Graduate, 1939; Junior ITE; reviewed book.		
		HOLCOMB, W. T., State Manager, Highway Planning Survey, Department of Highways.		
NEW HAMPSHIRE				
Concord		ENGEL, J. N., State Manager, Highway Planning Survey, State Highway Department.		
		GARDNER, FREDERICK A., Public Relations Engineer, State Highway Commission, Patriot Building.		
				PERSON, HERBERT C., Planning Engineer, State Planning and Development Commission; Bureau for Street Traffic Research Short Course, 1937.
Wolfeboro				CLAFLIN, RUSSELL G., Box 577; Bureau for Street Traffic Research Graduate, 1938.
NEW JERSEY				
Camden				TAYLOR, S. HERBERT, County Engineer, Camden County, Court House Annex; Bureau for Street Traffic Research Short Course, 1937.
Elizabeth	*			KELCEY, GUY, Sales Manager, Signal Service Corporation; Member ITE; reviewed book.
				MACK, IRVING, Manager, Electrical Division, Signal Service Corporation; Assoc. ITE.
Irvington			KAFKA, WALTER A., Traffic Engineer, Town Engineering Department.	
Newark		THOMAS, P. P., State Manager, Highway Planning Survey, 900 Calumet Building, 17 William Street.		
New Brunswick	*			TIPTON, LAWRENCE B., Professor; Head, Bureau of Public Safety, Rutgers University Extension Division, 77 Hamilton Street; Affil. ITE; reviewed book.
Trenton	*			GIFFIN, HAROLD W., Engineer, Survey and Plans, State Highway Department; reviewed book.
	*	VEY, ARNOLD H., State Traffic Engineer, Motor Vehicle Department, State House; Member ITE; reviewed book.		
NEW MEXICO				
Roswell		ECCLES, W. R., Traffic and Safety Engineer, Traffic and Safety Division, State Highway Department.		
Sante Fe		ABELARD, A. R., State Manager, Highway Planning Survey, P. O. Box 958.		
NEW YORK				
Albany				BENEDICT, WALTER C., Junior Civil Engineer, Department of Public Works, Division of Highways, State Office Building; Bureau for Street Traffic Research Graduate, 1939.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Albany (*Cont.*)				GEORGER, ROBERT C., Engineer of Highway Transport, State Department of Public Works; Secretary, State Traffic Commission.
				McCLUNG, D. A., State Manager, Highway Planning Survey, Division of Highways, State Office Building.
Babylon				CLARK, EDWIN F., Assistant Civil Engineer, Division of Highways, N. Y. State Department of Public Works; Member ITE.
		*		SHAPIRO, SIDNEY M., Assistant Chief Engineer, Long Island State Park Commission; reviewed book.
Binghamton				DONOVAN, F. W., District Engineer, Department of Public Works, Division of Highways, 71 Frederick Street; Bureau for Street Traffic Research Short Course, 1939.
				WOOD, FRANK B., Traffic Engineer, District No. 9, Department of Public Works, 11 Avon Road; Bureau for Street Traffic Research Short Course, 1939.
Brooklyn				GREENSHIELDS, BRUCE D., Adjunct Professor of Civil Engineering, Polytechnic Institute of Brooklyn; Assoc. ITE.
				HOOVER, KENETH M., Superintendent of Traffic, Board of Transportation, New York City, 385 Flatbush Avenue Extension; Assoc. ITE.
Buffalo				POWELL, WILLIAM B., Consulting Traffic Engineer, 171 Beard Avenue; Member ITE.
New York City				AVINS, NATHAN, Inspector of Light and Power, Police Department Engineering Bureau, 400 Broome Street; Assoc. ITE.
				BARTON, EUGENE A., Traffic Engineer, Traffic Division, National Conservation Bureau, 60 John Street; Junior ITE.
				BRINCKERHOFF, HENRY M., Consulting Engineer, Parsons, Klapp, Brinckerhoff & Douglas, 142 Maiden Lane; Member ITE.
		*		CHERNIACK, NATHAN, Analyst, Port of New York Authority, 111 Eighth Avenue; Member ITE; reviewed book.
		*		COLE, W. GRAHAM, Director of Safety, Welfare Division, Metropolitan Life Insurance Company, One Madison Avenue; Member ITE; reviewed book.
		*		CURTIN, JOHN F., Highway Engineer Economist, American Petroleum Industries Committee, 50 W. 50th Street; Bureau for Street Traffic Research Graduate, 1938; reviewed book.
				DUDLEY, RALPH W., Patrolman, Traffic C Precinct, N. Y. Police Department, 138 West 30th Street; Bureau for Street Traffic Research Graduate, 1938.
		*		FRENCH, PATERSON, Committee on Public Administration, Social Sciences Research Council, 261 Broadway; reviewed book.
		*		GARRETT, PAUL, Vice-President and Director of Public Relations, General Motors Corporation, 1775 Broadway; reviewed book.
		*		GIBALA, JOHN T., Assistant Engineer, Police Department Engineering Bureau (in charge of Traffic Engineering), 400 Broome Street; Member ITE; reviewed book.
		*		GILMAN, ROGER H., Statistician, Port of New York Authority, 111 Eighth Avenue; Bureau for Street Traffic Research Graduate, 1937; Junior ITE; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
New York City (*Cont.*)				**GOODRICH, ERNEST** P., Consulting Engineer, 175 Fifth Avenue; Member ITE.
	*			**HAMMOND, HAROLD** F., Director, Traffic Division, National Conservation Bureau, 60 John Street; Bureau for Street Traffic Research Graduate, 1931; Member ITE; reviewed book.
				HEMMINGS, HARRY H., 255 West 108th Street; Member ITE.
	*			**HOLMES, ROBERT S.,** Traffic Engineer, Traffic Division, National Conservation Bureau, 60 John Street; on leave, The Calverton, 1673 Columbia Road, Apartment 409, Washington, D. C.; Bureau for Street Traffic Research Graduate, 1939; Junior ITE; reviewed book.
	*			**KRAFT, MERWYN A.,** Accident Prevention Engineer, American Transit Association, 292 Madison Avenue; Bureau for Street Traffic Research Graduate, 1937; Affil. ITE; reviewed book.
				O'NEIL, WILLIAM H., Lieutenant of Traffic, Port of New York Authority, 111 Eighth Avenue; Bureau for Street Traffic Research Short Course, 1937.
				PAVER, JOHN, Paver-Sills Co., 2344 Lincoln Building, 60 East 42nd Street; Affil. ITE.
				ROCHESTER, THOMAS W., Chief Engineer of Police Department, City of New York, 400 Broome Street.
	*			**ROYSTER, ROBERT F.,** Accident Research Assistant, American Transit Association, 292 Madison Avenue; Bureau for Street Traffic Research Graduate, 1938; reviewed book.
				SIMON, WILLIAM J., Executive Assistant, Greater New York Safety Council, 60 East 42nd Street; Bureau for Street Traffic Research Graduate, 1937.
	*			**SIMPSON, HAWLEY S.,** Research Engineer, American Transit Association, 292 Madison Avenue; Member ITE; reviewed book.
				WELCH, ALDEN W., Research Editor, The American City, The Municipal Index, 470 Fourth Avenue; Affil. ITE.
				WELSH, JAMES W., Senior Engineer, Ford, Bacon & Davis, Inc., 39 Broadway; Member ITE.
	*			**WHITNEY, ALBERT W.,** Consulting Director, National Conservation Bureau, 60 John Street; reviewed book.
	*			**YORDAN, EDWARD L.,** Bureau for Street Traffic Research Graduate, 1937; reviewed book. Editorial Consultant, Bureau for Street Traffic Research, Yale University.
Rochester				**BROWN, LEON R.,** Research Engineer, Rochester Transit Corporation, 267 State Street; Member ITE.
				MICHAEL, WILLIAM, Assistant Traffic Engineer, City of Rochester, 52 City Hall; Bureau for Street Traffic Research Short Course, 1940.
				YOUNG, R. HARRISON, Traffic Engineer, Division of Engineering, Department of Public Works, City of Rochester; Bureau for Street Traffic Research Short Course, 1938, 1939.
Schenectady	*			**FISCH, FRED W.,** Director, Bureau of Traffic and City Planning, City Hall; Assoc. ITE; reviewed book.
Syracuse	*			**MACKALL, KENNETH W.,** Traffic Signal Engineer, Crouse-Hinds Company; Member ITE; reviewed book.

LOCATION		HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Troy					**STEINER, BARNET**, Junior Engineer in charge of Street Lighting and Traffic Engineering, City Hall; Bureau for Street Traffic Research Short Course, 1937, 1939.
NORTH CAROLINA					
Charlotte					**HAYDEN, JAMES G.**, Chief Engineer, Horton Motor Lines, Inc., 1001–31 South Clarkson Street; Assoc. ITE.
Raleigh			**BURCH, JAMES S.**, State Manager, Highway Planning Survey, State Highway and Public Works Commission.		
	*		**MITCHELL, ADOLPHUS**, Senior Traffic Engineer, Traffic Engineering Department, State Highway and Public Works Commission; Bureau for Street Traffic Research Graduate, 1940; Junior ITE; reviewed book.		
					TUCKER, HARRY, Professor, Highway Engineering, Director, Engineering Experiment Station, North Carolina State College, State College Station; Affil. ITE.
NORTH DAKOTA					
Bismarck			**CRAWFORD, CHARLES J.**, State Manager, Highway Planning Survey, Department of State Highways.		
					HAGEN, O. L., Office Maintenance Engineer (including traffic engineering functions).
OHIO					
Akron					**DRAKE, THOMAS R.**, Assistant City Engineer, City Planning Commission; Bureau for Street Traffic Research Short Course, 1937.
	*				**ROSEMOND, JAMES P.**, Managing Editor, Beacon Journal, reviewed book.
Bellefontaine	*				**McPECK, HAMILTON C.**, The Daily Examiner; reviewed book.
Bucyrus	*				**PETERS, ROWLAND R.**, Telegraph Forum; reviewed book.
Canton	*				**KOREN, JOSEPH M.**, Reporter, The Canton Repository; reviewed book.
Chillicothe	*				**HARWOOD, RODNEY B.**, Division Traffic Engineer, State Highway Department, Savings Bank Building, Paint and Main Streets; Bureau for Street Traffic Research Short Course, 1940; reviewed book.
	*				**OYER, HOWARD C.**, Managing Editor, Gazette & News-Advertiser; reviewed book.
Cincinnati	*				**BECKENBACH, CHARLES G.**, Traffic Engineer, Department of Public Utilities, City Hall; Member ITE; reviewed book.
					CALLAHAN, J. CAL, Traffic Research Engineer, 2327 Symes Street; Junior ITE.
	*				**CLARK, C. C.**, Junior Engineering Aid in Traffic, 134 City Hall; on leave—Hd. Battery, 62nd Field Artillery Brigade, APO No. 37, Camp Shelby, Mississippi; Bureau for Street Traffic Research Graduate, 1938; Junior ITE; reviewed book.
					SEGOE, LADISLAS, Planning and Traffic Consultant, 35 East Seventh Street; Member ITE.
	*				**LaRUE, JOHN W.**, The Enquirer; reviewed book.
	*				**RAWNSLEY, ELLIS**, Times-Star; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Cleveland	*			**CRAWFORD, JOHN A.,** The Plain Dealer; reviewed book.
	*			**DVORAK, WILLIAM,** The Press; reviewed book.
				JOHNSON, V. L., Traffic Engineer, Department of Public Safety.
	*			**NESS, ELIOT,** Director, Department of Public Safety; reviewed book.
				REID, KIRK M., Illuminating Engineer, General Electric Company, Nela Park; Affil. ITE.
Columbus				**ALTVATER, CHARLES H.,** Ohio Department of Highways, Designing Engineer; Bureau for Street Traffic Research Short Course, 1940.
	*			**DEETZ, RUSSELL S.,** District Traffic Engineer, Department of Highways; Bureau for Street Traffic Research Short Course, 1940; Bureau for Street Traffic Research Graduate, 1941; reviewed book.
	*			**DODUIT, OAKES C.,** Assistant Traffic Engineer, Ohio Department of Highways, Division of Traffic and Safety, Room 809–B State Office Building, 65 South Front Street; Bureau for Street Traffic Research Short Course, 1940; reviewed book.
	*			**ECKHARDT, HAROLD G.,** Assistant Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1939; reviewed book.
				FISHER, GEORGE J., District Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Graduate, 1941; Bureau for Street Traffic Research Short Course, 1940.
				GUTHRIE, J. ROBERT, Traffic Engineer, Division of Traffic Regulation and Engineering, 413 Short Street; Bureau for Street Traffic Research Short Course, 1938, 1939; Assoc. ITE.
	*			**HENDERSON, RALPH D.,** President and Publisher, The Citizen Publishing Company; reviewed book.
				HOPKINS, V. J., Superintendent of Route Marking, Division of Traffic and Safety, Department of Highways; Bureau for Street Traffic Research Short Course, 1940.
	*			**MECKSTROTH, J. A.,** Editor, Ohio State Journal; reviewed book.
	*			**METCALF, HARRY D.,** Chief Engineer of Maintenance, Department of Highways, State Office Building, South Front Street; reviewed book.
	*			**MONNETT, ROBERT,** District Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940; reviewed book.
	*			**NEAL, HARRY E.,** Chief Engineer, Division of Traffic and Safety, State Highway Department; Member ITE; reviewed book.
				PANCOAST, D. F., Col., State Manager, Highway Planning Survey, 600 Ohio-Hartman Building, 4th and Main Streets.
				SMITH, GORDON E., Investigator, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
	*			**SOURS, HAL G.,** Director of Highways, Department of Highways; reviewed book.
				SWINEFORD, FRED E., Civil Engineer, State Highway Department, 903 Ohio Department's Building; Bureau for Street Traffic Research Short Course, 1940.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Columbus (*Cont.*)	*			TARBOX, FREDERICK C., Assistant Traffic Engineer, Division of Traffic and Safety, Ohio Department of Highways; Bureau for Street Traffic Research Graduate, 1937; Junior ITE; reviewed book.
	*			WEBB, JOHN, Copy-reader, Columbus Dispatch; reviewed book.
	*			WILSON, ALVA H., District Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940; reviewed book.
Coshocton	*			BOYD, LESTER S., Tribune and Times Age; reviewed book.
Dayton	*			HERRON, LAWRENCE, Herald and Journal; reviewed book.
Defiance	*			PETERS, RALPH W., Editor, Defiance Crescent-News; reviewed book.
Dover	*			HOOPINGARNER, ARTHUR A., President and Publisher, Daily Reporter; reviewed book.
Dresden	*			ELLWOOD, COSMO C., The Transcript; reviewed book.
Findlay	*			HEMINGER, I., Republican Courier; reviewed book.
Fostoria	*			HOPKINS, FRED M., Publisher and Editor, Daily Review; reviewed book.
Ironton	*			BARON, K. J., The Tribune; reviewed book.
	*			COLLETT, CHARLES L., The News; reviewed book.
Logan	*			McKINLEY, CHARLES G., Publisher, The Daily News; reviewed book.
London	*			TRACEY, RICHARD L., Madison Press; reviewed book.
Lorain	*			MALOY, FRANK, Editor, Lorain Journal; reviewed book.
Mansfield	*			WOODMAN, KEN, Telegraph and Sunday Editor, News-Journal; reviewed book.
Marietta	*			SOUTHWICK, ERMAN D., Marietta Times, Associate Editor; reviewed book.
Marion	*			BYRD, ROBERT W., City Editor, Marion Star; reviewed book.
Minerva	*			BOERNER, LEONARD O., Editor, Minerva Leader; reviewed book.
Mingo Jct.	*			KERTEL, P. A., Publisher-Editor, News and County Reporter; reviewed book.
Portsmouth	*			HESS, CARL, Portsmouth Times; reviewed book.
Sabina	*			GASKINS, JAMES R., News Record; reviewed book.
Sidney	*			CHACEY, D. KENNETH, Division Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940; reviewed book.
Toledo				ROBINETTE, PAUL S., Traffic Engineer (Ohio Registration No. 6931), City of Toledo; Bureau for Street Traffic Research Short Course, 1937.
				SMITH, W. SHERMAN, Assistant Professor, Civil Engineering, University of Toledo; Assoc. ITE.

LOCATION		HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Utica	*				BRINKERHOFF, R. R., Utica Herald; reviewed book.
Versailles	*				GUNCKLE, LEO J., Versailles Policy; reviewed book.
Williamsburg					FUHR, RALPH D., Owner and Editor, Williamsburg Times; also Editor and General Manager, Clermont Courier of Batavia; reviewed book.
Zanesville	*				PHILLIPS, JOHN B., Assistant to Conservation Supervisor of City Schools; reviewed book.
OKLAHOMA					
Chickasha	*				VANDIVIER, DAVE, Publisher, Chickasha Express; reviewed book.
Oklahoma City	*				BOWERS, DOUGLAS A., Statewide Highway Planning Survey, Oklahoma State Highway Commission, State Capitol Building; Bureau for Street Traffic Research Graduate, 1939; reviewed book.
	*				BURTON, RICHARD L., Traffic Engineer, State Department of Public Safety; Bureau for Street Traffic Research Short Course, 1938, 1940; reviewed book.
					JONES, DUDLEY, State Manager, Highway Planning Survey, State Highway Commission, State Capitol Building.
	*				MUELLER, HAROLD L., Associate Editor, The Daily Oklahoman and Oklahoma City Times; President, Oklahoma State Safety Council; reviewed book.
OREGON					
Portland	*				FOWLER, F. T., Traffic Engineer, Department of Public Works; reviewed book.
					GORTER, CHARLES W., Parking Supervisor, 401-c City Hall; Bureau for Street Traffic Research Short Course, 1939.
					LeROY, HOLDEN M., Traffic Engineering Aide, City of Portland; Bureau for Street Traffic Research Graduate, 1941.
					WELLER, WILLIAM J., Assistant Traffic Engineer, City of Portland; Bureau for Street Traffic Research Short Course, 1937.
Salem	*				BALDOCK, ROBERT H., Chief Engineer, Oregon State Highway Commission; reviewed book.
	*				BEAKEY, JOHN, Traffic Engineer.
					BEAKEY, JOHN, State Manager, Highway Planning Survey, Oregon State Highway Department; Member ITE; reviewed book.
					HAVENNER, JOSEPH E., Office Assistant, Traffic Division, State Highway Department; Bureau for Street Traffic Research Graduate, 1941.
					WALTON, JAMES J., Assistant Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
PENNSYLVANIA					
Erie					BOSSART, S. PAUL, Secretary Engineer, City Planning Commission; Bureau for Street Traffic Research Short Course, 1937.
Harrisburg					ALBRIGHT, C. C., State Manager, Highway Planning Survey, Brotherhood Building, 6th and Maclay Streets.
	*				NOBLE, CHARLES M., Special Highway Engineer, Pennsylvania Turnpike Commission, 11 North 4th Street; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Harrisburg (*Cont.*)	RIEGELMEIER, RAY F., Traffic Engineer, Pennsylvania Department of Highways; Member ITE.			
				TRANSEAU, T. ELMER, Director, Bureau of Highway Safety, Department of Revenue, Commonwealth of Pennsylvania, 504 Finance Building; Member ITE.
Johnstown				MYERS, DWIGHT T., Traffic Engineer, City of Johnstown; Bureau for Street Traffic Research Graduate, 1941.
Lancaster				BARDZIL, THOMAS J., Advertising, Box 13; Bureau for Street Traffic Research Graduate, 1936.
Philadelphia	*			CANNING, WILLIAM S., Engineering Director, Keystone Automobile Club, Broad and Vine Streets; Member ITE; reviewed book.
				FLYNN, EDWARD V., Assistant Traffic Statistician, 785 City Hall; Junior ITE.
				GALLAGHER, JOHN F., Traffic Signal Engineer, Department of Public Safety, Room 785, City Hall; Assoc. ITE.
				HUNTER, JOHN H., St. Anthony Club, 32 South 22nd Street; Assoc. ITE.
				MATTHEWS, WALTER W., Managing Director, Philadelphia Safety Council, 1129 Walnut Street; Member ITE.
	*			MITCHELL, ROBERT A., Traffic Engineer, Traffic Engineering Division, Department of Public Safety, Room 785, City Hall; Member ITE; reviewed book.
				MURRAY, H. BRUCE, 2037 North 12th Street; at present, Junior Naval Architect, Mare Island, Navy Yard, Calif.; Junior ITE.
				SWIFT, WILLIAM P., Director, Safety and Traffic Engineering, Automobile Club of Philadelphia, A.A.A.; Bureau for Street Traffic Research Short Course, 1937.
Pittsburgh				CUNNINGHAM, CHARLES S., Traffic Planner, Bureau of Traffic Planning, 908 City-County Building; Member ITE.
				HOUGH, ALVIN C., Senior Engineer, Traffic and Transportation Department, Pittsburgh Railways Company, 435 Sixth Avenue; Member ITE.
				McINTYRE, LEWIS W., Consulting Engineer, 313 Boulevard of Allies, Member ITE.
	*			McNEIL, DONALD M., Traffic Engineer, City of Pittsburgh, 908 City-County Building; Member ITE; reviewed book.
				VOLTZ, WILLIAM H., Electric Signal Design Engineer, Bureau of Traffic Planning, 617 Second Avenue; Member ITE.
				WATSON, A. J., JR., Junior District Traffic Engineer, Pennsylvania Department of Highways, 908 Wabash Building, Junior ITE.
State College				RICE, PHILIP X., Associate Professor, Electrical Engineering, Pennsylvania State College; Affil. ITE.
Swissvale				ASHE, FRANK C., Consulting Engineer, Kopp Glass, Inc.; Affil. ITE.
RHODE ISLAND				
Providence	*			EATON, RALPH W., Traffic Engineer, City of Providence, City Hall; Member ITE; reviewed book.
				LEEMAN, WILLIAM H., Traffic Control Engineer, Division of Roads and Bridges.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Providence (*Cont.*)				MANCINI, PHILLIP S., Deputy Public Service Engineer, City Hall; Bureau for Street Traffic Research Short Course, 1937; Assoc. ITE.
				MANNING, LESTER P., State Manager, Highway Planning Survey, 39 Arline Street.
				PIKE, CHARLES A., Federal Products Corporation, Engineering Department; Bureau for Street Traffic Research Short Course, 1936.
SOUTH CAROLINA				
Columbia				* BRADLEY, WILLIAM W., Engineer Assistant, Traffic Engineering Division, State Highway Department; Bureau for Street Traffic Research Graduate, 1939; reviewed book.
				* DIBBLE, WORTHAM W., Assistant Traffic Engineer, State Highway Department; Bureau for Street Traffic Research Graduate, 1938; Junior ITE; reviewed book.
				GALLETLY, WELLINGTON O., Engineer Assistant, Traffic Engineering Division, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
				HOWARD, HARRY, JR., Office Assistant, Traffic Engineering Division, State Highway Department; Bureau for Street Traffic Research Graduate, 1941; Junior ITE.
				HUDSON, W. F., State Manager, Highway Planning Survey, 2nd Floor, Waters Building, Corner Sumter and Senate Streets.
				* SMITH, WILBUR S., Traffic Engineer, South Carolina State Highway Department; at present, Research Assistant, Bureau for Street Traffic Research, Yale University, New Haven, Connecticut; Bureau for Street Traffic Research Graduate, 1937; Assoc. ITE; reviewed book.
				* WILLIAMSON, J. STANLEY, Chief Highway Commissioner, State Highway Department; reviewed book.
				* WATERFALL, CHARLES H., Associate-Professor of Economics, University of South Carolina; reviewed book.
				THOMAS, GEORGE S., Office Assistant, Traffic Engineering Division, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
SOUTH DAKOTA				
Pierre				HOWARD, L. D., Traffic Safety Engineer, State Highway Commission.
				MITCHELL, B. J., State Manager, Highway Planning Survey, State Capitol Building.
TENNESSEE				
Chattanooga				BURNETT, T. M., Assistant Division Construction Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
Knoxville				BAILEY, LEONARD C., Design Engineer, City Engineer's Office; Bureau for Street Traffic Research Short Course, 1940.
				GARLAND, HARDY DOUGLAS, Division Safety Engineer, Tennessee Valley Authority; Bureau for Street Traffic Research Short Course, 1938.
				* MENHINICK, HOWARD K., Director, Department of Regional Studies, Tennessee Valley Authority; reviewed book.

LOCATION		HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Knoxville (*Cont.*)					**WHITE, DUNCAN A.,** Associate Professor of Mechanical Engineering, University of Tennessee; Bureau for Street Traffic Research Short Course, 1940.
Memphis	*				**SLOVER, HERBERT L.,** City Traffic Engineer, Public Works Department; Bureau for Street Traffic Research Graduate, 1939; reviewed book.
Nashville					**CANTRELL, LEON T.,** State Highway Department, Engineer Supervisor, Division of Research and Statistics; Bureau for Street Traffic Research Short Course, 1940.
					CRAIG, JOHN L., Engineer, Safety Division, Department of Highways and Public Works.
					CRAIG, C. W., Traffic Engineer, Police Department
					HOLLEY, JAMES E., Engineer Analyst, Division of Research and Statistics, State Highway Department; Bureau for Street Traffic Research Short Course, 1940.
					McEWEN, T. C., State Manager, Highway Planning Survey, Division of Research and Statistics, Department of Highways and Public Works, 426 Sixth Avenue North.
					TURNER, E. M., Traffic Engineer, Department of Highways and Public Works.
TEXAS					
Austin	*				**BOSSY, HERBERT G.,** Assistant Engineer Road Design, State Highway Department; Bureau for Street Traffic Research, 1939; reviewed book.
					EDWARDS, G. G., State Manager, Highway Planning Survey, State Highway Building.
	*				**FRANKE, EDWIN G.,** Assistant Maintenance Engineer, State Highway Department; Bureau for Street Traffic Research Short Course, 1939; reviewed book.
	*				**GREER, MAURICE V.,** Assistant Traffic Engineer, Texas Highway Department; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
	*				**PHILLIPS, HARRY S.,** Traffic Engineer, State Highway Department; reviewed book.
	*				**SWAIN, ROBERT O.,** Senior Assistant Traffic Engineer, Texas Highway Department; Bureau for Street Traffic Research Graduate, 1938; Assoc. ITE; reviewed book.
Beaumont					**SOUTHWELL, JOHN D.,** Traffic Engineer, City of Beaumont.
Dallas					**KLAPPROTH, WALTER H.,** City Traffic Engineer, City Hall; Member ITE.
Houston	*				**WILLIER, THOMAS E.,** Director, Traffic Engineering Department, Room 901, City Hall; Bureau for Street Traffic Research Graduate, 1937; Assoc. ITE; reviewed book.
San Antonio					**WILSON, HORACE J.,** Zoning and Planning Engineer; Bureau for Street Traffic Research Short Course, 1937.
					RITTGERS, VIRDEN A., City Traffic Engineer, Police Department; Assoc. ITE.
UTAH					
Salt Lake City	*				**ANDERSON, W. L.,** Design Engineer, State Road Commission, 421 State Capitol; Bureau for Street Traffic Research Short Course, 1939; reviewed book.
					BASTOW, LEON F., Traffic Engineer, Police Department.
	*				**DIEFENDORF, ADELBERT,** Head of Civil Engineering Department, University of Utah; reviewed book.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Salt Lake City (*Cont.*)				* **ERICKSEN, ELROY L.,** Assistant Traffic and Safety Engineer, Utah State Road Commission, 439 State Capitol; Bureau for Street Traffic Research Graduate, 1940; reviewed book.
				GROO, R. WHITNEY, Superintendent, Utah Highway Patrol, State Capitol.
				HAMMOND, W. D., Chairman, State Road Commission; reviewed book.
				HILL, C. E., State Manager, Highway Planning Survey, State Road Commission, 439 State Capitol Building.
				* **KNOWLTON, EZRA C.,** Chief Engineer, Utah State Road Commission; reviewed book.
				* **KUNZ, FOSTER M.,** Traffic and Safety Engineer, Utah State Road Commission, 439 State Capitol; Bureau for Street Traffic Research Graduate, 1939; Junior ITE; reviewed book.
				SCHWENDIMAN, GLENN, Drivers Licensing Division, Motor Vehicle Department; Bureau for Street Traffic Research Student, 1941.
VERMONT				
Montpelier				**COLEMAN, ABNER W.,** Traffic Engineer, Vermont Department of Highways.
				FARRINGTON, H. F., State Manager, Highway Planning Survey, State Highway Department.
				RICKER, EDMUND R., Assistant Traffic Engineer, Vermont Highway Department; Bureau for Street Traffic Research Graduate, 1941.
				SARGENT, HUBERT E., Commissioner of Highways and Chief Engineer, Vermont Department of Highways.
VIRGINIA				
Arlington				**BURRAGE, ROBERT H.,** Major, Engineers Corps, United States Army; home address, 2803 24th Street North; Assoc. ITE.
Fort Belvoir				**EVERETT, WARREN S.,** Captain, Corps of Engineers, The Engineer Board; Bureau for Street Traffic Research Short Course, 1940.
Norfolk				**JORDAN, FENTON G.,** Assistant Engineer, City of Norfolk; Bureau for Street Traffic Research Graduate, 1941.
Richmond				**BALDWIN, DAVID M.,** Safety Engineer, State Police and Safety Division of Motor Vehicles; Junior ITE.
				* **COLEMAN, GEORGE P.,** President, Bondholders Mortgage Corporation, 805 State-Planters Bank Building; reviewed book.
				MARYE, BURTON, JR., State Manager, Highway Planning Survey, State Highway Building, 14th and Broad Streets.
				ROBERTSON, GILES M., Safety Engineer, Department of Highways, Central Highway Office Building; Assoc. ITE.
WASHINGTON				
Coulee Dam				**MERRYMAN, HAROLD W.,** Junior Engineer, U. S. Bureau of Reclamation; Bureau for Street Traffic Research Graduate, 1938.
Olympia				**CARSTEN, WINSTON H.,** Traffic Department, Washington Department of Highways; Bureau for Street Traffic Research Graduate, 1941.
				DUNN, ROBERT E., Traffic Department, State Highway Department; Bureau for Street Traffic Research Graduate, 1941.
				* **FRITTS, CARL E.,** Traffic Engineer.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
Olympia (*Cont.*)				**FRITTS, CARL E.**, State Manager, Highway Planning Survey, State Highway Building; Assoc. ITE; reviewed book.
				* **HARROLD, DEWITT HUNTER**, Assistant Traffic Engineer, Department of Highways; Bureau for Street Traffic Research Graduate, 1938; reviewed book.
				* **MURROW, LACEY V.**, Director of Highways; on leave, Lieutenant Colonel, c/o Office Chief of the Air Corps, Plans Section, Room 5033, North Interior Building, Washington, D. C.; reviewed book.
Seattle				* **BOLLONG, J. W. A.**, Traffic Engineer, Engineering Department, 400 County-City Building; Member ITE; reviewed book.
Spokane				**AUMACK, HARRY F.**, City Planning and Traffic Engineer.
WEST VIRGINIA				
Charleston			**PRINGLE, T. B.**, Division Engineer.	
				PRINGLE, T. B., State Manager, Highway Planning Survey, 314 Professional Building, Quarrier and Broad Streets.
				RADCLIFFE, HARRY, Senior Engineer, in charge of Safety, Maintenance Division, State Road Commission.
WISCONSIN				
Madison				**MARTIN, THOMAS M. C.**, Assistant Highway Engineer-Economist, Public Roads Administration, 717 Langdon Street; Bureau for Street Traffic Research Graduate, 1938.
				MAURER, CLAUDE N., Traffic Engineer, State Motor Vehicle Department, State Office Building; Member ITE.
				* **O'MEARA, EDWARD J.**, Traffic Engineer, Wisconsin Highway Commission; Member ITE; reviewed book.
				RADER, LLOYD F., Professor, Civil Engineering, Mechanical Engineering Building, University of Wisconsin; Affil. ITE.
				RYAN, W. D., State Manager, Highway Planning Survey, State Highway Commission.
				VAN HAGAN, CHARLES E., Junior Assistant Highway Engineer, State Highway Commission; Bureau for Street Traffic Research Graduate, 1941.
				VOLK, WAYNE E., Senior Assistant Highway Engineer, State Highway Commission; Bureau for Street Traffic Research Graduate, 1941.
Milwaukee				* **BRUENING, MARTIN C.**, Traffic Control Engineer, Bureau of Electrical Service, Room 713, City Hall; Assoc. ITE; reviewed book.
				* **ILGNER, HOWARD F.**, Superintendent and Chief Engineer, Bureau of Electrical Service, Room 713, City Hall; Member ITE; reviewed book.
Wausau				**BRAUN, FRED W.**, Vice President and Chief Engineer, Employers Mutual Insurance Co.; Bureau for Street Traffic Research Short Course, 1939.
				* **LOWELL, JOHN W.**, Safety Engineer, Employers Mutual Liability Insurance Co.; Bureau for Street Traffic Research Graduate, 1939; reviewed book.
WYOMING				
Cheyenne			**SIMMONS, JOHN L.**, Traffic Engineer.	
				SIMMONS, JOHN L., State Manager, Highway Planning Survey, State Highway Commission.

LOCATION		HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS
CANADA					
Montreal Quebec	*				BAKER, HOWARD M. A., Formerly Traffic Engineer, Montreal. At present, Captain O. C. No. 14 Company, Canadian Provost Corps, C.A.S.F., Place Viger Depot, Canada; Bureau for Street Traffic Research Graduate, 1937; Affil. ITE; reviewed book.
					GABOURY, ARTHUR, Lieutenant Colonel, Secretary-General, Province of Quebec Safety League, Office 38, Mt. Royal Hotel; Affil. ITE.
Toronto Ontario					IRVIN, WILFRID F., Research Engineer, Toronto Transportation Commission, 35 Yonge Street; Member ITE.
					LeMAY, TRACY D., Commissioner of City Planning, City Surveyor and City Traffic Engineer, Room 333, City Hall; Assoc. ITE.
					WILSON, NORMAN D., 388 Young Street; Member ITE.
ENGLAND					
Suffolk					COLQUHOUN, ROBIN S., Area Engineer, Ministry of Transport, 118 Northgate Street, Bury St. Edmunds; Bureau for Street Traffic Research Graduate, 1937.
MEXICO					
Mexico City	*				BRACHO, MIGUEL E., Sec. Oper. y Conserv. Der. de Depto. Conservacion, Dir. Nac. de Caminos, Sria. de Communicaciones y O.P.; reviewed book.
	*				RIVERA, JOSÉ R., Secretary, Pan American Division, American Road Builders' Association, Paseo de la Reforma 46; reviewed book.
NEW ZEALAND					
Wellington	*				STEWART, FREDERICK H., Assistant City Engineering Department; Bureau for Street Traffic Research Short Course, 1938; reviewed book.
					FORSYTH, ANDREW E., Civil Engineer, Transport Department, New Zealand Government, Wellington (C.1.); Assoc. ITE.
					GOLDIE, G. N. T., Town Planner and Traffic Engineer, Wellington City Corporation; Assoc. ITE.
					HUME, HARRY L., Commonwealth Fund Service Fellow. On leave from Public Works Department, New Zealand Government; Bureau for Street Traffic Research Student, 1941.
PALESTINE					
Tel-Aviv	*				ARONOV, ELIEZER, Deputy Road Engineer, Municipal Corporation of Tel-Aviv; Bureau for Street Traffic Research Short Course, 1939; reviewed book.
SOUTH AFRICA					
Johannesburg	*				DORFMAN, SAVILLE, City Engineer's Department; on leave, in Active Service, The South African Engineer's Corps,—address 15 Fortescue Road, Yeoville, Johannesburg. Bureau for Street Traffic Research Graduate, 1939; reviewed book.
					HAYTON, ALEXANDER A., Chief Traffic Officer; now in Active Service with British South Africa forces. Mail addressed attention of Mrs. I. R. Hayton, 23 Auckland Avenue, Auckland Park; Affil. ITE.
					NORMAN, F.W., License Officer, City Council; Affil. ITE.

LOCATION	HEAD STATE TRAFFIC ENGINEERING DIVISION	HEAD HIGHWAY PLANNING SURVEY	HEAD CITY TRAFFIC ENGINEERING DIVISION	ADDITIONAL CLASSIFICATIONS

SOUTH AMERICA

Barcelona-Venezuela

CABRERA, ISAAC T., Safety Engineer, Mene Grande Oil Co., Apartado 45, Barcelona-Venezuela; Junior ITE.

TERRITORY OF HAWAII

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